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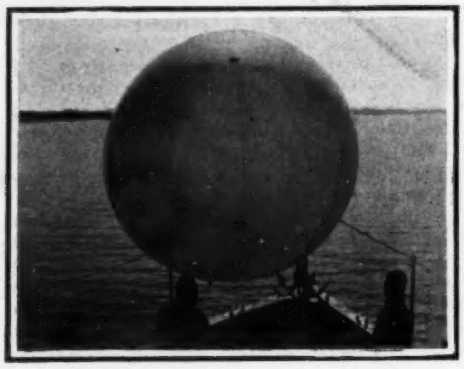
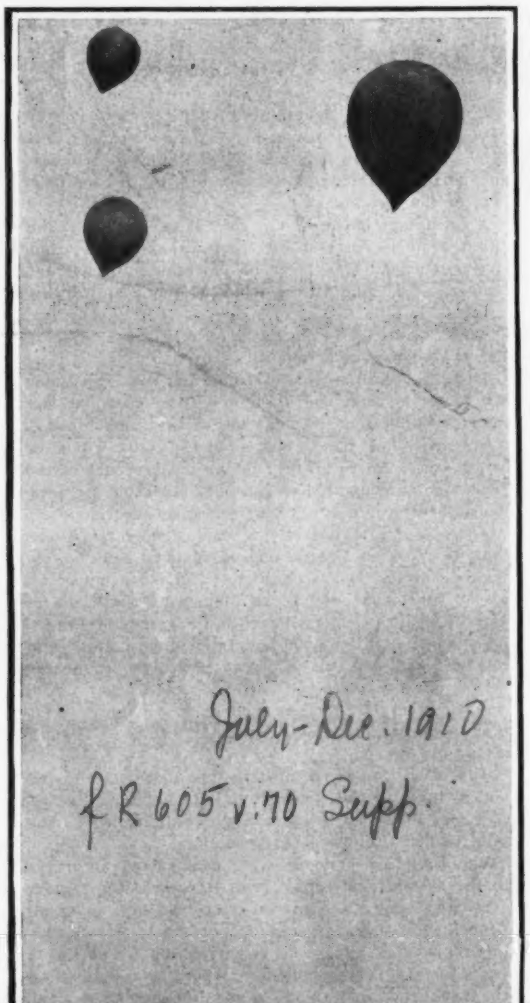
SENDING UP A PILOT BALLOON.



PREPARING FOR A BALLOON ASCENT.

A BALLOON ASCENT ON THE VICTORIA NYANZA.



A KITE ASCENT ON THE VICTORIA NYANZA.

ONE OF THE BOX KITES USED.

CONTROLLING A KITE WITH A HAND WINDLASS.

NOTING THE COURSE OF PILOT BALLOONS WITH SPECIAL THEODOLITES. THE PILOT BALLOONS ARE LIBERATED TO ASCERTAIN THE DIRECTION AND VELOCITY OF THE WIND BEFORE THE LIBERATION OF REGISTERING BALLOONS.

GERMAN METEOROLOGICAL INVESTIGATIONS IN EAST AFRICA.

TYPICAL AIR EXPLORATION.

THE EAST AFRICAN EXPEDITION OF THE ROYAL PRUSSIAN METEOROLOGICAL OBSERVATORY.

An expedition for the study of atmospheric conditions in equatorial regions and the specific investigation of monsoons and their causes was sent out in July, 1908, under the auspices of the Royal Prussian Meteorological Observatory.

The expedition was conducted by Prof. Berson of the Observatory and Dr. Elias, editor of the well-known aeronautic magazine, Illustrirte Aeronautische Mitteilungen.

The expedition lasted ten weeks, and the expenses were borne by private enthusiasts. Although only partially successful in accomplishing its aims, the results obtained were very valuable and interesting from various points of view. The reports of the leaders of the enterprise prove, indeed, that the Dark Continent offers as fascinating a field of adventure and discovery to the man of science as to the mighty hunter, with even worthier trophies as the prizes of daring and skill.

In the study of monsoons answers were sought to the following questions: In what manner do monsoons arise? What masses of air are transported northward? How is equilibrium established? I. e., Where and in what way are these masses of air returned to their original position?

The value of answers to these queries can hardly be overestimated in view of the relation that these moisture-laden winds bear to the food supply of many millions of the human race.

Failure of the monsoons means failure of the rice crop along the shores of the Indian Ocean and even far inland, and this spells not only famine for a vast bulk of the Asiatic populace, but widespread political discontent and far-reaching commercial disturbances.

For a number of years a very careful study of the trade winds has been carried on, a study which has resulted in some unexpected discoveries. For example, these winds, formerly supposed to be an essential part of the general atmospheric circulation, in reality extend only to a height of 4,500 meters (14,764 feet), while above this comparatively thin layer is a relatively thick stratum of air quite without motion. Above this, in turn, at a great height, we find the "anti-trade winds," which restore equilibrium by carrying the air back to the north.

But this study has been conducted almost entirely, so far as the tropics are concerned, in oceanic areas. Consequently, questions have arisen as to whether the conditions of the atmosphere over continental areas would be similar or notably different with regard to such points as vertical changes of temperature, the upper inversion zone, etc.

As a natural corollary, similar questions have been suggested with regard to the temporary or seasonal winds known as monsoons.

These monsoons are caused primarily by the excessive heating of the southern portions of the continent of Asia. The heated air, rising, gives place to volumes of cooler air sucked in from the Indian Ocean. Thus is created the strong wind known as the southwest monsoon, whose violence is explained by the fact that an area of low pressure extends for many thousands of kilometers from the far south of the Indian Ocean to the Himalayas or beyond.

It is this moisture-laden wind which brings rain to India, and there is a close relation between the rainy season in East Africa and this monsoon or its transformation into the normal northeast trade wind or "winter monsoon."

Since the sending up of kites and free unmanned balloons from the interior of a tropical wilderness offers peculiar and almost insuperable difficulties, it must be regarded as an extremely fortunate circumstance that the gigantic inland sea Victoria Nyanza is so situated, lying as it does in the tropics and not too far from the East African coast, as to make feasible the employment of oceanic methods of meteorological study. Thus, if balloons are used, it is easier to find and recover them, after descent, from the surface of a vast body of water than from the interior of a savage and sparsely settled tropical country.

These considerations induced Prof. Berson and Dr. Elias to make the Victoria Nyanza the headquarters of their expedition. But, as they desired also to make observations on the east coast and on the open ocean, they planned kite and balloon ascensions from three points—Lake Victoria itself, some part of Daressalam on the coast, and the Seychelles group of islands (about 500 miles east, in the Indian Ocean).

They also communicated with the Indian authorities in an effort at obtaining their co-operation by having similar experiments conducted at various points in the path of the monsoon, as at Simla, at Bombay, and at the Kodaikhanal Observatory in the southern part of the Deccan.

A subsidiary object of the enterprise was the acquisition of merely statistical information of the atmosphere, such as knowledge of the regular or average temperatures, humidities, wind currents at varying heights.

Such knowledge is obviously of very great value in the new science of aeronautics.

Thus, in localities where strong and constant winds are found to reign, no attempt will be made, at any rate for the present, to make use of flying machines.

On the other hand, places where light winds or calms are found to prevail during a large part of the year will be recognized as specially favorable for aeronautic sports or military and scientific experiments.

Apropos of this, one of the conclusions reached was that the Victoria Nyanza offered an ideal location (as regards atmospheric conditions) for such purposes, and it may some day be as famous as the arena of aerial sports as Ormond Beach is for automobile races. At a height of from 4,700 meters an almost dead calm reigned; and though the observation extended over a period of only ten weeks, the general uniformity of conditions in the tropics renders it highly probable that a similar state would prevail during the whole of the dry season.

The most improved modern methods of meteorological investigation were employed, including the use of kites, sounding balloons, registering balloons, and pilot balloons followed by theodolites.

The sounding balloons were constructed according to the system devised by Prof. Hergesell, the famous acrologist, who has been the right-hand man of Count Zeppelin for so many years. According to this system, the registering apparatus is carried up by means of two Assmann rubber balloons. About 50 meters below the apparatus is fastened a cork float with a small water anchor. When a great height has been reached, one of the balloons bursts, the other is unable to sustain the weight of the apparatus, and the whole contrivance falls to the surface of the water, where it floats supported by the cork and buoyed up by the inflated balloon, while the anchor acts as a drag to retard its progress, so that it may be more quickly reached and rescued by the search boat.

In clear weather the balloon could be followed with the naked eye up to a height of 20,000 meters (65,600 feet) until it had reached an absolute distance from the observer of 30 kilometers (18.6 miles). Experience showed that the recovery should be made within a period of an hour and a half; otherwise, there was danger of complete loss of the apparatus.

Some apprehension had been felt lest the superstitions of the negroes should interpose obstacles or even instigate hostility. Accordingly, at the outset, the rulers or sultans of the various tribes were assembled, and urged to do all in their power to further the purposes of the expedition, which were explained in as simple terms as possible. The natives accepted these quite simply as merely a new sort of white man's magic for coercing the powers of nature.

The phenomenal calm of the atmosphere at a short distance above the surface of Lake Victoria made it impossible to perform any satisfactory experiments with kites, as there was not wind enough to make them rise. It was not until the Indian Ocean was reached that the kites proved useful. The balloons, on the other hand, gave very good results.

From the end of July to the third of September ten successful ascensions were made, in one of which a height of 19,800 meters was recorded with a temperature of —84 deg. C., the surface temperature at the time being 26 deg. C. (at 1,150 meters above sea level). This proved that even at the equator the upper inversion zone exists, though it may not reach to the maximum height. Still more interesting was it to find that above the "steady equatorial east wind" there is found at the greatest height a west wind!

In general, the decrease in temperature according to height was remarkably great. Repeatedly a dead calm was found up to great heights; in one case the balloon stood vertically above the theodolite at a height of 17,000 meters (55,760 feet)!

Out of twenty-three registering apparatus eight were lost. The greatest heights attained were as nearly as can be estimated, 19,800 meters, 17,100 meters, 16,800 meters, 11,300 meters, 9—10,000 meters. Several reached from 6—9,000 meters.

At a height of 17,000 meters (15.6 miles) in round numbers on two consecutive days temperatures of —52 and —76 deg. C. were recorded, while at the ground level the variation is only a few degrees throughout the year.

Since no kite could be made to ascend above 1,100 meters, it was determined to cross the lake in the hope that wind conditions would be found better on the west side. The result was disappointing, however, and a short time after the lake was left and work was begun over the Indian Ocean, where kites were used with more success.

The trip across the lake was the first one known to have been made, and constant soundings were taken for the benefit of future navigators. The whole interior of the lake has been hitherto uncharted and unmeasured, though there are rumors of a group of islands inhabited by cannibals within its limits; and the Sesse Islands farther north, where Dr. Koch stayed while studying the sleeping sickness, are of course well known.

One of the most useful results of this experimental expedition may be considered its value as a pioneer.* It has blazed the way for future work and more important discoveries.

RECENT PROGRESS IN WIRELESS TELEGRAPHY.

It is announced that the English coast stations of the Marconi International Marine Communication Company have been purchased by the British Post Office, which has also acquired the right to use, for the next fourteen years, all existing and future patents of Marconi, which relate to the operation of these stations. The sum paid to the company is about $67,000. The stations at Poldhu and Clifden will continue to be operated by the Marconi Company, for communication between England and the continents of Europe and America.

Prof. Rossi has devised a new wireless telegraph receiver, which he calls a convector. The apparatus consists essentially of a very fine iron wire, suspended vertically and carrying a small mirror at its middle point. This wire is traversed by an alternating current of low frequency, and oscillates between two bar magnets. The oscillations are projected by the mirror upon a scale in the form of a luminous band, the length of the luminous band begin to fluctuate in a aerial electric waves, but as soon as these waves reach the wire, the amplitude of its oscillation and the length of the luminous band begin to fluctuate in a manner which corresponds to the character of the messages sent out from the transmitting station. The signals can be recorded by photography.

Capt. Hovland of the Norwegian navy has invented a printing wireless telegraph receiver, which operates in a manner similar to the Hughes and Boudot printing telegraphs and is not influenced by stray waves.

The Telefunken Company and the Lepel Wireless Telegraph Syndicate have been experimenting with new systems of wireless telegraphy, in which the Hertzian waves produce characteristic musical notes, which can be very easily distinguished from the harsh and rattling noises produced by the receivers of other systems.—La Nature.

*The pioneer investigation of the isothermal stratum in the tropics is due to a Franco-American expedition sent out jointly by M. Teisserenc de Bort and A. Lawrence Rotch in 1905-6 to sound the atmosphere in the intertropical region of the Atlantic, and not to the German expedition of 1908. In the Scientific American of July 2nd a communication from Mr. Rotch will be found of interest in this connection.

ELECTRIC LIGHTING AND POWER STATISTICS.

LARGE PERCENTAGES OF INCREASE IN 1907 SHOWN BY CENSUS BUREAU'S REPORT.

The commercial and municipal central electric light and power stations in the United States in 1907 numbered 4,714; reported $1,096,913,622 as the cost of construction and equipment; earned $175,642,338, of which $169,614,691 was for electric service including $125,755,114 for lighting; expended $106,205,149; employed 12,990 salaried officials and clerks, who were paid $11,733,787, and also 34,642 wage-earners who received $23,686,537; operated 10,150 primary-power machines, with 4,032,365 horsepower capacity; had 12,173 dynamos, with a kilowatt capacity of 2,709,225; and their output, in kilowatt hours, was 5,862,276,737. Of the total number of lamps wired for service, there were: Arcs, 555,713; incandescent, 41,445,997; and other varieties, 162,338.

These statistics are set forth in the United States Census Bureau report on the census of central electric light and power stations in the United States in 1907, now in press, prepared under the supervision of William M. Steuart, chief statistician for manufactures, assisted by T. Commerford Martin, of New York city, and Frank L. Sanford. It will be submitted by Director Durand to Secretary Nagel, of the Department of Commerce and Labor, and will be ready for general distribution in about a month.

THE CLASSES OF STATIONS.

The central stations from which reports were received are classed as "commercial," or those operated under private ownership, and "municipal," or those operated by municipalities. These two classes are each further divided into "purely electric" and "composite," the former being those devoted solely to the generation and sale of electric energy. The majority are of the "purely electric" class. The "composite" stations are those engaged in the electric business and also in other industries, such as waterworks, gas plants, etc. The municipal stations frequently sell large quantities of electricity for commercial uses.

The percentages of increase in 1907, as against 1902, the date of the last census of this kind, are 30.2 in the total number of stations; 117.3 in the cost of construction and equipment; 104.9 in gross income; 91.5 in total expenses; 35.6 in the number of primary-power machines, and 120.3 in their total horse-power capacity; 123.5 in kilowatt capacity of dynamos; 201.7 in kilowatt capacity of the alternating single-phase and polyphase current dynamos; 133.8 in the output of stations; 44.1 in the number of arc lamps; and 127.8 in the number of incandescents.

INCORPORATED COMPANIES IN THE MAJORITY.

One of the distinctive features of the report is the statement that nearly three-fourths of the stations reported at each census were operated by incorporated companies. Individual ownership was next in importance, the number of stations being less than one-fifth of the total at each census. Firms showed but little proportionate change at both censuses.

A comparison of the totals for the "purely electric" and "composite" central electric stations shows that in 1907 about three-fifths of the income and cost of construction and equipment was connected with the former and two-fifths with the latter.

Nearly two-thirds of the commercial central stations were reported as "purely electric," and something more than one-third as "composite," and the proportions represent their respective importance.

Nearly four-fifths of those in the "composite" group are commercial stations.

It is said to be noteworthy that both the commercial and the municipal stations share in the uniformly large percentage of increase for the "composite" stations, which appears to indicate that the distinctive characteristics of the two principal classes of stations are much less marked than formerly.

As a rule the central electric stations are concentrated in the most populous states, and at points within these states from which the largest percentage of the population can be served economically. New York, Pennsylvania, Illinois, and Ohio, containing together 29.6 per cent of the total population of the United States, reported 1,296 electric stations, or 27.5 per cent of the total number in operation during 1907, and the annual output of these stations amounted to 2,553,745,890 kilowatt hours, or 43.6 per cent of the output of all stations in the United States.

WESTERN DIVISION'S SHOWING.

Comparing the proportion of population with that for the number of stations, the proportion of stations was larger than that for population in the North Central and Western divisions and smaller for the North Atlantic, South Atlantic, and South Central divisions. One of the most pronounced features of the central-station industry is the large percentage showing for the Western division, which in 1907, having less than 5,000,000 population, as compared with the population of upward of 11,000,000 and 16,000,000 for the South Atlantic and South Central divisions, respectively, reported a greater primary horse-power and larger dynamo capacity and more incandescent lamps wired for service than the latter two divisions combined. In per capita showing, the North Atlantic division was second in rank, the North Central third, the South Atlantic fourth, and the South Central fifth.

The report states that the development of the alternating current by means of the single-phase or polyphase dynamo, referred to in the report for 1902, has continued since that census until, at the census of 1907, the kilowatt capacity of this class of machines represented 82 per cent of the total dynamo capacity of all central stations. In many instances large plants are now located at places where water power is available for the generation of the current, but at great distances from where the current is used.

Statistics relative to thirty-four selected cities are presented in the report. These are: Chicago, New York, Philadelphia, St. Louis, Cincinnati, Cleveland, Denver, Indianapolis, Louisville, Minneapolis, New Orleans, St. Paul, Washington, D. C.; Worcester, Mass.; Dayton, Ohio; Des Moines, Iowa; Duluth, Minn.; Erie, Pa.; Evansville, Ind.; Holyoke, Mass.; Mobile, Ala.; Reading, Pa.; San Antonio, Tex.; Wilmington, Del.; Anderson, Ind.; Cumberland, Md.; Flint, Mich.; Hannibal, Mo.; Lewiston, Me.; Northampton, Mass.; Oklahoma City, Okla.; Paducah, Ky.; Richmond, Ind.; and Shreveport, La.

These thirty-four cities had 75 stations in 1907 and 70 in 1902, the character of ownership of which, in 1907, was as follows: Corporate, 61; and municipal, 14. In 1902, 58 were corporate; 11, municipal; and 1, individual.

THE USES OF ELECTRICITY.

While the principal income of central stations is derived from lighting and stationary-motor service, electricity is being used for a constantly increasing variety of purposes. As evidenced in the statistics of these cities, the central electric stations in them reported for 1907 an income from electric-railway service amounting to $1,960,551, as against $138,275 in 1902; from sales of electric energy to other electric companies in 1907, $779,728; from heating, cooking, welding, etc., in 1907, $117,560, as compared with $23,451 in 1902; and from charging automobiles in 1907, $135,121, as against $24,775 in 1902.

In 1907 nearly one-fourth of the primary power for the entire 4,714 central stations was connected with the 75 stations in these cities. The proportion of steam power to the total primary power in these cities was 92.5 per cent in 1907 and 98.7 per cent in 1902, as compared with 65.2 per cent and 75.4 per cent, respectively, for the United States.

As illustrative of the extensive use of the steam turbine in the more thickly settled communities, 55.6 per cent of the total power reported for them was by the stations in these thirty-four selected cities. The gas engine was very little used in these cities, only four engines, with a total of 60 horse-power, being reported in 1907.

Exclusive of the horse-power of the gas engines, which was comparatively insignificant, the horsepower capacity reported by all central stations in the United States in 1907 was about two-thirds steam and one-third water. In 1902 the proportions were about three-fourths steam and one-fourth water.

For the thirty-four cities, in 1907 more than nine-tenths was steam and less than one-tenth water, while in 1902 practically all the primary power was steam.

Notwithstanding the gain in kilowatt capacity of dynamos, there was a general decrease in their number, owing to the fact that the average capacity of the dynamos in 1907 was much greater than was reported in 1902.

The extent of the predominance of the small central station is evidenced by the fact that 81.8 per cent of all stations in 1907 and 87.8 per cent in 1902 were under 500-kilowatt capacity, while considerably more than one-half of all—64.4 per cent in 1907 and 71.5 per cent in 1902—were under 200-kilowatt capacity. The commercial stations made the only increase in the class of largest dynamo capacity.

THE "COMPOSITE" STATIONS.

Of the 4,714 central electric stations, the "composite" central stations, or those which were operated in connection with other industries, numbered 2,066. These stations were associated with 2,306 industries of various kinds, the excess of industries being due to the fact that a single central station may be associated with several other industries. The association of central stations with water works and gas plants is the most common, and for the municipal plants there was practically no other. For the commercial stations there were 995 operated in connection with such public services as water works, gas works, street railways, steam heating, and the manufacture of ice, and 573 stations operated in connection with some other business. The central stations associated with such industries as sawmills, gristmills, manufactured ice, and cotton gins are likely to be of secondary importance, and owe their existence to the facility with which surplus primary power, by use of the dynamo, may be converted into electrical energy and transmitted for service as light or power to nearby or remote points.

Of the various industries mentioned, the manufacture of illuminating gas comes into the most direct competition with the generation of electrical energy.

Comparing the sale of electrical energy with that of gas, the report shows an increase in 1907 of 101.5 per cent for the central electric stations and 62.3 per cent for the gas plants.

In 1907, 329 stations reported that they also operated gas plants, but this by no means represents the extent to which the consolidation of the interests of the two industries has been carried, since it does not cover instances wherein the whole, or a controlling portion, of the stock of one industry has been acquired by the other, and the companies are operated under separate management regardless of stock ownership. There is a growing tendency to merge the two industries, partly to avoid the sharp competition whenever they are common bidders for the same class of business.

PROPOSED MONT BLANC TUNNEL.

The construction of a tunnel under Mont Blanc, which would constitute a second outlet to Italy and the Mediterranean, independent of Switzerland, in addition to the old Mont Cenis tunnel, has been discussed in France for the past ten years. The project has now assumed a definite shape, and the ministry of public works has adopted a plan for a tunnel extending from the valley of Chamounix, in France, to Entreves, in the Italian valley of the Dora, a distance of about 8 miles, two-thirds of which is in French territory. The projected tunnel will be large enough to accommodate two railway tracks, and its highest point will be 4,200 feet above sea level. The conditions are similar to those of the Mont Cenis tunnel, except that the new tunnel will be buried beneath a far loftier and more extended mountain mass, in the interior of which a higher rock temperature will be encountered. As there is no reason to expect such abnormal local conditions as were found in the Simplon tunnel, this temperature is estimated at about 113 deg. F.

According to Prometheus, continuous cooling by currents of air and water will consequently be required during the progress of the work. For this reason the cost of construction is estimated at $12,000,000, equal to that of the Mont Cenis tunnel, despite the great improvements in boring machinery, explosives and methods that have been made since the construction of the old tunnel. On the other hand, only five years are allowed for the time of construction, because the geological conditions are very favorable, and there is little probability of encountering masses of debris subjected to enormous pressure, soft strata or formidable inundations. An additional outlay of $6,000,000 will be required for the construction of lines of railway from St. Gervais les Bains to Chamounix and from Aosta to Entreves. In the following table the principal features of the projected work are compared with those of other great Alpine tunnels:

Name of Tunnel.	Time of Construction.	Length in Miles.	Elevation of Highest Point Above Sea Level, in Feet.	Height of Mountain Above Tunnel, in Feet.	Character of Rock.	Maximum Rock Temperature, Deg. Fahr.	Average Daily Progress, in Feet.	Cost, in Millions of Dollars.	Cost per Mile, in Millions of Dollars.
Mt. Cenis.	1857 / 1871	7.6	4380	5425	Slate, limestone and calcareous schist....	8	5.2	12.0	1.6
St. Gothard	1872 / 1881	9.3	3788	5602	Gneiss-granite, mica-gneiss, mica schist....	89	9.8	12.6	1.3
Arlberg	1880 / 1884	6.4	4300	2401	Gneiss and mica schist....	66	14.7	8.1	1.3
Simplon ...	1898 / 1906	12.4	2312	7005	Gneiss, mica schist and calcareous schist.	132	13.5	15.7	1.3
Mt. Blanc*.	5 years	8.1	4231	7446	Granite	113	16.4	12.0	1.5

* Projected.

The Simplon is pierced by two parallel tunnels, each of which is traversed by a single railway track.

Each of the other mountain tunnels is single, and accommodates two tracks.

PLANT PARASITES.

EXPERIMENTAL PARASITISM IN THE HIGHER PLANTS.

BY DR. D. T. MACDOUGAL.

FLOWERING plants which live as parasites upon other organisms are exemplified to the common observer by the mistletoe, and the farmer has further unwelcome knowledge of the yellowish cord-like stems of the various species of dodder which infest his fields of wheat and flax. These and other seed plants which are parasitic on crops are a serious economic menace in places. About 2,500 species of parasitic seed plants are known, which are included in two hundred genera, representing ten great families. All degrees of dependence are exhibited by the members of these families, some having a normal green color, and capable of independent existence when they do not readily find a host, while others have lost their chlorophyl, and with it the capacity for building up complex foods. Degeneration and atrophy have been carried so far in some cases, that the entire plant including the flowers and ovaries does not come above the surface of the ground.

The shoots and aerial parts of plants are subject to constant scrutiny, so that parasitism on the branches of trees and other large forms is readily detected. The underground members are not so well known. The careful examination of the root systems of a few desert plants by Dr. W. A. Cannon at the Desert Laboratory has resulted in the discovery that Krameria, a small leguminous shrub, is parasitic on a number of hosts, a fact that has hitherto eluded observation, although the roots have been used to furnish color adulterants for many years. Thorough examination of the common plants would doubtless result in evidence that would double the number of parasites, and give a total that would include above five per cent of all flowering plants which exhibit dependent nutritive habits.

Any study of parasitic plants leads to a consideration of the mycorrhizal forms, or plants which form associations with filamentous fungi in which the thread-like hyphæ enwrap or penetrate the roots of the higher plants. Such partnerships generally result in some advantage to the higher plant, and are followed by immediate changes similar to those exhibited by species known as parasites. These changes include a lack of differentiation of the tissues, even in the seed and embryo; a lessened development of the shoot and root, a reduction of the leaf surface, and diminished production of chlorophyl. Taken together, the parasitic plants and those which enter into partnerships with fungi in the soil, comprise nearly half of the seed plants of the world. It is evident that the existence of a tendency affecting half of the higher plants, which leads toward atrophy of the vegetative organs and the development of specializations of structure and habit seen in associations and dependent nutrition, must have a tremendous significance for the student of evolution.

Singularly enough, the changes shown by parasites are not due directly or alone to the food received by the host or symbiont, as no similar changes may be seen when plants are fed with solutions of organic materials which might be obtained by parasitism. The entire set of complicated conditions furnished by active association with a living host or co-operating organism seems to be necessary to induce the changes described.

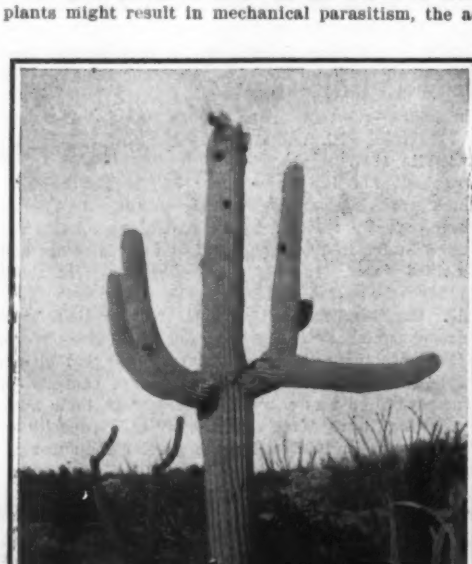
The studies of the general anatomical features presented by the families, the members of which exhibit parasitism, have so far failed to yield any conclusions as to the morphological features which might be favorable to such arrangements. The specialization of tissue which ensues when a seed plant becomes parasitic fortuitously, is far more striking than any simple anatomical character which might be interpreted to indicate a predisposition to the dependent habit of nutrition in autophytes.

Theoretical considerations lead to the belief that it is to purely physiological features and to the habits of green plants that we must look for the conditions favorable to the origination of parasitism. Evidence to the effect that a number of green plants may take inorganic compounds through their membranes is increasing, and this capacity would facilitate parasitism as at present understood. The course of development of the absorbing organs, their mechanical relations to the bodies of other plants, and the concentration of the fluids in the cells of the possible parasite, would be features to which attention would naturally be directed in any attempt to ascertain the method of origin of this method of nutrition. Some results of importance with respect to this matter are presented herewith.

The mechanical adhesion of the bodies of seed plants which would make parasitism possible, might be brought about by three different ways. The roots growing thickly interlaced in the soil might unite or penetrate each other, or adventitious roots arising from internodes any place on the aerial stems might pierce the bodies of other plants, or seeds lodging in the bark or in the wounds of a plant might germinate and send absorbing organs into the tissues of the possible host. Of these methods, that of incidental root parasitism seems to bear the greater probability of recurrence, and to be illustrated by some very striking examples. Peé-Laby has recently described a case in which the main root of a plant of a passion-flower vine has become attached to a root of Japanese burning bush, forming a specialized absorptive tissue, and undergoing general atrophy of its own root system, in a manner suggestive of a highly developed degree of parasitism, although but little indication of this was to be seen in the shoot of the Passiflora.

MEXICAN GRAPEVINE GROWN ON PRICKLY PEAR FOR ONE YEAR.

The germination of seeds on the bodies of other plants might result in mechanical parasitism, the advantage being purely one of position with respect to light, and this feature is illustrated by many hundreds of examples, particularly abundant in tropical forests. The development of any form of nutritive dependence out of such purely mechanical relations has not yet been demonstrated, although various workers, notably Peirce, have made extensive demonstrations of the possibility of short-lived annuals completing their entire cycle of existence as parasites upon enforced hosts, in the tissues of which their seeds were germinated, or were set at an early stage of their existence.



PRICKLY PEAR GROWING ON GIANT TREE CACTUS.

It is also reported that grape culturists in France insert seeds of the vine in old living stems of the same plant a short distance above the ground, and that the developing plantlets send roots through the tissues which eventually reach the soil and ramify in it. Many of the phenomena consequent upon grafting operations also are of interest in this connection. Such unions may be of all degrees of intimacy varying from perfect grafts, where the vessels unite, to other cases in which the scion is separated from the stock by a layer of dead tissue, through which there can be no free interchange of material as between a branch and a main stem, but instead a phase of parasitism exists. These arrangements in fact present the simplest accomplishments of parasitism artificially produced.

A large number of instances are known in which the scion after uniting with the stock, or during the process, sends out adventitious roots, which strike downward and penetrate the tissues of the host, simulating parasitism mechanically, as would be done whenever the roots of any plant accidentally bore through those of another. No real or important transfer of food material has been demonstrated in such cases, and the roots showed no prolonged existence.

The whole subject thus illustrated seemed to offer unusual opportunities for the study of the origin of "adaptations" or of acquisition of specialized characters. Various stages of parasitism are known, ranging from plants which derive only a small amount of nutrition from some incidental host to instances where everything is taken from the supporting organism. The induction of even a slight degree of dependence of one seed plant upon another or the intensification of the habit in a form already showing a tendency to parasitism would be taken as evidence of first-class importance in the interpretation of the way in which new characters are acquired and developed in the history of the plant.

In the organization of an experimental attack on this problem at the Desert Laboratory, it was thought advantageous to use plants furnished with a large water balance, and hence capable of existence for extended periods, independent of any additional supplies. Such forms have great inertia; that is, cuttings or sections of the body may carry on existence in a fairly normal manner for a long time without additional supplies, and during this time regeneration and the formation of new absorbing organs may take place with adjustment to conditions of parasitism. Observations on material of this character might well furnish exceptional opportunities for detecting the conjunction of conditions or developmental stages which would facilitate the assumption of dependent relations in nutrition. The use of massive plants also rendered it easy to make the chemical analyses necessary to determine the concentration of the cell sap, which was thought to be of importance in this connection. The most direct method of ascertaining the relative osmotic value of the sap of two plants would be by freezing tests of the expressed juice.

The native flora around the Desert Laboratory at Tucson, Arizona, is rich in succulents which furnish the conditions noted above and the material chosen for experimentation in the present work included chiefly several Opuntias which were used as both host and parasite, normal and in etiolated condition: *Carnegiea gigantea*, exclusively as host, *Echinocactus wislizenii* as host, *Fouquieria splendens* as both host and parasite, *Cissus digitata* and *C. laciniata* from Southern Mexico, *Agave americana*, *Cotyledon macrantha*, and *Tradescantia* as parasites, in addition to a number of other forms, of which but slight use was made. After some preliminary tests, the arrangement of the material in the dependent relation was begun seriously in January, 1908, and many hundreds of preparations have been set up since then.

The methods of experimentation employed consisted in making cuttings of the joints of prickly pears, Mexican grapevine, agave, and of other plants which were to be induced to live parasitically, and thrust these into a bed of sand until the raw surfaces were healed and regeneration with root formation had begun. Next a suitable cavity was cleanly cut in the flesh of a giant cactus or barrel cactus, or in the plant to be used as host, into which the base of the slip of the "xeno parasite" was thrust. The insertion was held in place by an adequate setting of plaster of Paris, and

the whole preparation was cared for as to shade and temperatures. If the inserted slip was capable of immediate adjustment to the new conditions, interesting results followed. The transfer of a plant from its original state to experimental arrangement described, however, is an extremely radical one, and involves serious disturbances of a group of functions. Thus, in the insertion of slips of one plant in the body of another, the development of the roots would necessarily be carried on in confined wound cavities, in which the only free oxygen available from the growth of these organs would be that coming from the intercellular spaces of the host and by transfusion. The lack of this substance alone would operate to prevent parasitism, while in other cases the speedy formation of oxidases and peroxidases in the wound tissues, together with the ready formation of corky layers and mucus, would hinder root formation.

None of these factors would be detrimental to actual grafting, since in this case the union of living cells and the intermediate tissues would proceed best when free aeration was prevented.

Some of these experimentally arranged parasites have endured for more than two whole seasons, forming roots which penetrated the soft bodies of the hosts in some instances, while other species absorbed juices directly through the epidermal surfaces of the healed bases of the slips inserted.

The spread and surface leaves and branches developed from the inserted parasitic slips were in all cases less than that of similar parts which still formed a part of the original plant from which cuttings were made. The lessened size and reduced leaf surface characteristic of parasites was thus seen as a direct response of the individual to dependent nutrition, foreshadowing the degradation or atrophy which reaches advanced stages in species which have followed a long course of parasitism.

After a great number of experimental trials had been made in which the failures proved no less interesting than the successes, a series of analyses was made to determine the concentration or osmotic activity of the sap of the species used in the tests.

The results of these analyses and of the general observations show that the Mexican grapevine with an osmotic activity of 15 (?) atmospheres was successfully parasitic on a small prickly pear (*Opuntia blakeana*) in which the mucilaginous juice had a pressure of 9 atmospheres and on the barrel cactus (*Echinocactus*) at a pressure of 6 atmospheres, but not on the giant tree cactus (*Carnegiea gigantea*) at 7 atmospheres by reason of the copious gummy exudation and fermentation products which follow wounds in making the necessary incision in the body of the host. Rooted joints of the prickly pear were parasitic on the barrel cactus (see above), especially when the slender cylindrical joints produced by the prickly pear when it is grown in darkness were used as parasites. The cylindrical prickly pear (*Opuntia veriscolor*) with a juice showing a pressure of 12 atmospheres was successfully parasitic on *Carnegiea*, and on *Echinocactus*. (See above.) Rooted cuttings of agave, or the common century plant, maintained themselves for extended periods upon Carnegiea and Opuntia, as it had a pressure of about 11 atmospheres.

A careful consideration of all the details gathered from the experiments showed that one plant might become parasitic upon another only when it possessed a sap having a higher osmotic activity and hence being capable of withdrawing sap from the body of the possible host. Other causes might intervene to prohibit parasitism even when the relative osmotic pressures were favorable, but such inequality was a necessity in all cases. It is to be noted that the pressure of the sap changes unequally in different species with the seasons, and that a plant which might have a higher osmotic pressure at one season would be incapable of acting as a parasite during other seasons with respect to any given host. The plants used in the tests were natives of arid areas and accumulate a relatively great amount of surplus water at times, thus lowering the osmotic activity of the sap, while during the drier seasons water is lost in such quantity as to increase the osmotic pressure. In none of the analyses of desert plants hitherto made has the sap been found to show a higher activity than that of the common lilac and other plants which have been known to display an activity equivalent to 25 atmospheres and even higher. It is to be noted also that many plants show a capacity for increasing the osmotic activity of the sap when the solution in the substratum becomes more concentrated, and this may play a very important part in the origination and development of parasites.

The relative acidity of the sap of two plants appeared to be of no importance in the determination of their capacity to enter into parasitic relations, quite contrary to a common supposition. The ready formation of wound tissue or the exudation of enzymatic products would act as a deterrent to a possible parasite, while the capacity for formation of adventitious roots or of absorptive organs from the surfaces of stems would be an opposing factor in the development of parasitic relations. The more important features of the specialization by which parasitism ensues may thus be put in the form of an algebraic equation, the reduction of which should indicate with some certainty the possibility of dependent nutrition between two plants.

Many instances of singular arrangements of two species were seen during the course of the observations in connection with the investigations described above. A large prickly pear with several well-developed joints was seen growing from the summit of a tall tree cactus 80 miles west of Tucson, in November, 1907. An individual of a smaller species was found occupying a cavity in an old knothole of a palo verde (*Parkinsonia microphylla*) near the Desert Laboratory, while another occupied a similar position on an acacia tree a few miles to the eastward. The unceasing distributional movements of species over the face of the world would undoubtedly operate to bring new pairs of species constantly under test conditions, and it is in accord with the known facts to suppose that new parasitic unions are being formed frequently in almost all kinds of habitats, while on the other hand, it is to be kept in mind that extinction lies beyond parasitism, as the inevitable atrophies which follow dependent nutrition must in the end bring the species to a precarious condition, in which the slightest untoward variation in its highly complicated environment would end its existence.

AGAVE AND OPUNTIA GROWING PARASITICALLY ON BARREL CACTUS. SCALE PLACED FOR NOTING NUTATION OF STEM.

The changes ensuing when a plant becomes parasitic may include some startling phenomena, as was illustrated by the action of the prickly pear used in the experiments. The structure of the heavy succulent jointed stems of the prickly pears presents no features which suggest movement, yet when etiolated cylindrical branches of these plants were inserted in the fleshy bodies of the barrel cacti, and had become well established, sweeping nutatory movements like those of a vine were set up which carried the tips through an arc of 180 degrees in thirty-six hours, the complete nutation occupying twice that length of time. Furthermore, these movements differed from other nutatory movements hitherto described by the fact that they were not accompanied by growth in length. So far as could be determined, the curvatures resulted from rhythmic alterations in the turgidity or osmotic activity of the cell sap on opposite sides of the thin stems, thus setting up a movement utterly foreign to the ordinary habits of the plant, and purposeless so far as its environmental relations were concerned.

The results of this and previous studies allow us to recognize the limiting factors, the operative conditions, and some of the facts as to the physiological nature of parasitism. Few specializations present their main features so clearly to the student. When the total body of evidence, however, is evaluated in the light of current theories, it is found that it is no easy matter to decide by what main methods of evolutionary procedure this adjustment or "adaptation" is attained, and how it is advanced from stage to stage.

Some alterations such as that of Passiflora on Euonymus are distinctly discontinuous, but in this particular instance it can not be shown that any permanent results would follow the occurrence of the dependent relation. Some features, however, such as the development of Haustoria on roots and stems would be a distinct mutation and well illustrated by Krameria, and supposedly also by Cuscuta. The taking on of absorptive functions by the epidermal cells of xeno parasites, as described in the present paper, is to be recognized as a distinct mutatory alteration.

A direct and immediate atrophy of the various organs of the shoot ensues as a result of the assumption of the parasitic relation, but the extreme stages of such reduction appear to have been reached by gradual changes although it is evident that such a conclusion is almost wholly inferential. The transition from autophytism to complete parasitism with attendant habitual characters appears to have been gradual, since species may be cited to illustrate all degrees of the alteration; but on the other hand, it is not impossible that the complete change may have been made at once in some forms. Nothing in the entire matter suggests progression or retrogression of all of the involved characters by one method alone.

Viewed from another angle, it may be seen that some of the alterations described may be taken to be directly interlocking, or reactive, essential and practically irreversible. Correlated with these, having no direct connection with originating external causes or limiting conditions, but inevitably consequent upon the primary alterations, are a number of secondary changes which may be the most obvious, but in reality of lesser importance. Modifications of the absorbent organs and of the nutritive systems would be included in the first, while incidental atrophies and other characters such as the striking nutatory movements described would be examples of the second. The ingenious and intricate and strained interpretations made to include all of the phenomena displayed by organisms which bear specialized relations to other organisms or to environmental factors, are in striking contrast with this view.

A good mechanical illustration of the alterations in an organism is of a drop of liquid, such as water, when allowed to rest upon a rough surface, which it will not wet. Under equable external conditions, such a drop would be approximately globular with all of its sectors practically equivalent. When placed upon a roughened surface, the shape of the drop would be altered, the sectors in contact with the hard external body would be markedly modified, the position of the centroid would not be the same as that of the free drop, and the non-engaged sectors would be altered to a degree corresponding to the directness of their connection with those in contact with the hard external objects.

CUTTINGS OF MEXICAN GRAPEVINE GROWING IN JOINTS OF PRICKLY PEAR.

With the further application of this illustration the study of the mode of adjustment of an organism to an environmental factor would entail a determination of the changes in the engaging sectors or engaging characters, the measurement of the effects of the external factors, an estimation of the limiting conditions, and the detection of connected variations in the other sectors, functions, or qualities of the living drop. Among the many other suggestive parallels that might be drawn is to be mentioned the mechanical fact that under the altered conditions of surface tension ensuing from contact with one set of hard objects, the drop is much more liable to be changed further, or to be broken up by other agencies acting upon the free or unengaged surfaces.

A NOTABLE BRIDGE.

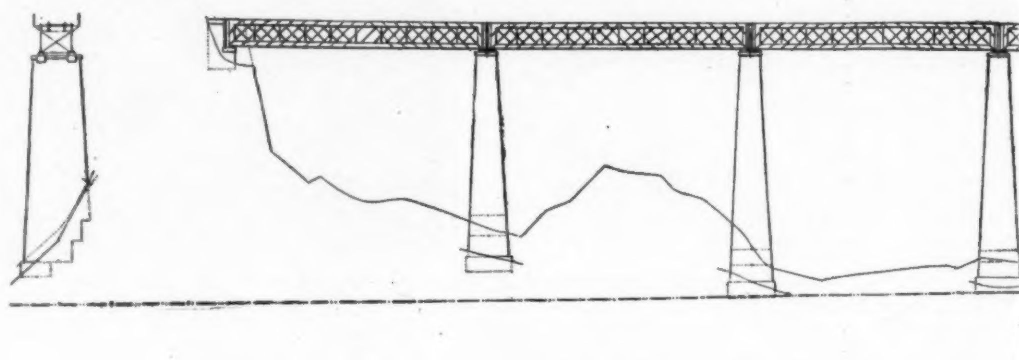
THE ASSOPOS VIADUCT ON THE PIRAEUS RAILWAY.

BY THE ENGLISH CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

One of the most notable works on the Piraeus railway, which has recently been opened in Greece, is the viaduct spanning the Assopos torrent and gorge between Dadi and Lianokladi. The country traversed by the line is among the most rugged in the Balkan peninsula; the mountains rise sharply, the spurs are steep and broken, and torn with deep, wide gulches. The most difficult of these proved to be the Assopos gorge, where it was seen that the structure necessary to span the ravine would have to be of large dimensions, entailing a considerable span in the main section, while the task of erection, owing to the nature of the site, would offer many interesting problems. In order to secure the best type of structure, the railway company decided to invite public competition, and the foremost bridge builders of France and other countries submitted tenders and designs. The successful tender was that of the Société de Construction des Batignolles of Paris. The general features of their design may be gathered from the accompanying illustration, which shows the bridge completed amid its wild surroundings. Through the courtesy of the builders we are enabled to give the following particulars:

The total length of the structure is 576 feet, the span of the main arch between the anchorages is 240 feet, and the height of the rails above the anchorages is nearly 80 feet. The rails are 330 feet above the bed of the torrent. The viaduct, which carries a single track, is situated upon a curve of about 1,330 feet radius, and has a grade falling toward Lianokladi of 1.875 per cent. The design finally adopted was prepared by M. Paul Bodin, the engineer in chief of the construction company. Broadly speaking, the main opening resembles the feet of a broadly-spread letter A with the floor system forming the crosspiece. The outer arms are perfectly straight and square, while the inner arms have a slight graceful curve to their central point of connection. The net results gained by this design are not only extreme lightness, consequent upon the lesser quantity of metal required, but great stability, with an appreciable economy in first cost.

On the Dadi side there are three approach spans of the deck truss type, each about 86½ feet in length, carried on masonry piers. The latter are of rectangular section, have practically a uniform height—about 80 feet—and have a batter on all sides of one in twenty. The width between trusses is 10 feet, by 14 feet over all at rail level. The extreme abutments of the viaduct are also carried out in masonry, while the feet of the arched span are similarly anchored in massive masonry plinths. The inner ends of the two truss spans which connect with the arch are fixed to the steelwork of the latter, the opposite ends of each span and truss resting on the masonry pier and abutment, respectively, and having the usual roller bearings.



ELEVATION AND

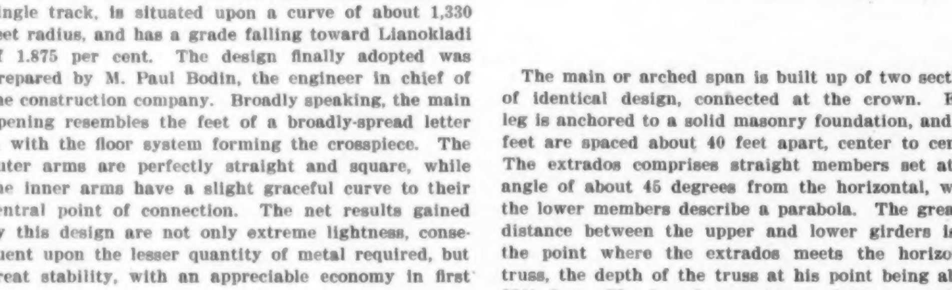
The main or arched span is built up of two sections of identical design, connected at the crown. Each leg is anchored to a solid masonry foundation, and the feet are spaced about 40 feet apart, center to center. The extrados comprises straight members set at an angle of about 45 degrees from the horizontal, while the lower members describe a parabola. The greatest distance between the upper and lower girders is at the point where the extrados meets the horizontal truss, the depth of the truss at his point being about 22½ feet. The legs have a taper of 14 per cent, so that at rail level the width conforms with that of the straight spans. The upper and lower girders of each truss was vertically divided into N panels, while horizontally the bracing is of the simple cross diagonal type. The feet are anchored to the masonry foundations by pins having a diameter of about 12 inches, while the connecting pin at the crown is about 6½ inches in diameter, one-half of the steel bearing being attached to the extremity of each half of the arch.

The erection of this bridge at the gorge was beset with numerous difficulties. The task was aggravated by the fact that the viaduct is entered from either side of the gorge through a tunnel, which somewhat handicapped movement. Working spaces, however, were cut in the mountains on either side of the ravine. An overhead cableway was set up spanning the gorge and the site. The material was brought up to the entrance to the tunnel, through which a temporary track was laid, and transported on to special cars which hauled the material to the foot of the works. Here each piece was picked up by hoisting tackle on the overhead cableway, and by means of a second hauling cable was transported from one side of the ravine to the other, or set exactly where required.

The straight deck spans were erected in the usual manner. It was the erection of the main span that occasioned the greatest difficulty. On the Dadi side, a timber falsework was erected around the anchorages to support the first sections of the arch. When the feet were anchored and the cross bracing riveted up, it was possible to continue the erection upward without further scaffolding to the level of the second verticals from the base. The inclined section was then temporarily secured by diagonal chords connecting with the outer members of the arch and the under side of the first panel of the overhanging straight span at the adjacent masonry pier, as shown in the accompanying illustration. This enabled erection to be continued up to the point where the inclined section met the rail level, and then similar temporary chords, practically horizontal, and carried to the same points as the temporary diagonal chords beneath the fixed span at the tower, were fixed to hold the whole section rigid. The same principle was adopted on the Lianokladi side, in which case, however, the straight deck span springing from the abutment to its connection on the arch timber falsework had to be set up. The second section of each half of the arch was then set in position and finally connected at the crown, a special arrangement devised by the engineer in chief, Paul Bodin, being adopted for this purpose.

The bearings for the straight spans, where they connect with the arch span on either side, are formed by vertically continuing the verticals of the N panels of the inclined members, and at this point the straight spans rest on rollers for temperature expansion and contraction movements. The arched span is set on the curve of about 1,330 feet radius, and makes an angle of 3 deg. 10 min. with the tangent on the Dadi, and of 5 deg. 30 min. on the Lianokladi side, respectively.

The total amount of steelwork in the whole structure is about 400 tons, of which the arch span comprises 190 tons, and the five straight spans, complete, the balance. The construction and erection of the bridge occupied thirteen months.



ERECTING ONE HALF OF THE MAIN ARCH.

GUTTA-PERCHA AND SUBSTITUTES.

THEIR PRODUCTION, MANUFACTURE, AND COMMERCIAL USES.

CONSUL-GENERAL ROBERT P. SKINNER, of Hamburg, furnishes the following information concerning gutta-percha, balata, jelotong, and other substitutes:

Gutta-percha is the dried milky juice of the trees of the genus Sapotacæ, chiefly of the species Palanquium and Payena, the habitat of which is the Malay Archipelago, more particularly Borneo, Sumatra, and Malacca. The name is derived from the Malay words "gettah" (gum) and "pertja" (crum or scrap). The annual production is estimated at 60,000 tons, of which North America, Great Britain, and continental Europe absorb one-third each. Balata is a similar substance, and jelotong is still another, both cheaper than and inferior to gutta-percha.

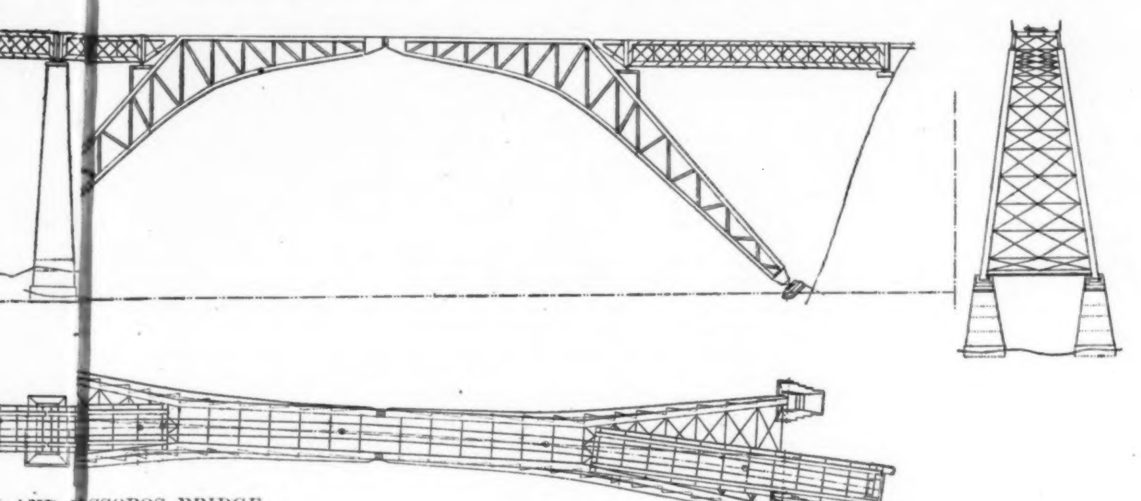
Gutta-percha is still obtained in a primitive manner. The trees are felled about 4½ feet above the ground and the bark peeled off at intervals of 5 to 6 inches, whereupon the juice begins to run out. If left standing undisturbed the juice forms a substance similar to curdled milk, to which salt or salt water is often added, in order to better separate the gutta-percha. The latter, so separated from the original juice, is kneaded and air-dried. In recent years it has been tried to replace this destructive method by the more rational one of tapping the trees, which renders it possible to draw the substance from the same tree for a number of years. According to a method recently invented by a Frenchman, gutta-percha is extracted from the leaves and branches of the trees by evaporation and distillation, such leaves and branches being shipped to Europe in a dried state. A similar process of obtaining gutta-percha mechanically is that of Prof. Jungleisch, by which not the bark, but other vegetable parts of the tree are used for its production, chiefly the leaves. These vegetable parts are pulverized in machines. By boiling this powder in sea water gutta-percha, free from all impurities, is separated from the mass in thin layers. Besides the advantage which these methods afford in sparing the trees, the product obtained is much in demand because of its purity, and high prices are paid therefor.

PROPERTIES OF GUTTA-PERCHA.

Either accidentally or intentionally, natural gutta-percha is adulterated by impure substances, such as sand, earth, bark, chips of wood, etc. Raw gutta-percha, such as is handled on the commercial markets in Asia, Europe, and the United States, forms irregular, oblong loaves, weighing 6 to 8 pounds, or 20 to 25 pound blocks, being reddish brown in color on the surface, lighter inside. The substance feels greasy and has a peculiar odor. At ordinary temperature gutta-percha is tough and viscid, but can be cut easily. It is slightly elastic but only in one direction, rending when stretched in opposite direction. If heated, particularly when dipped in warm water, gutta-percha turns soft at 48 deg. C. (118 deg. F.); at a temperature of 55 to 60 deg. C. (131 to 140 deg. F.), it attains a very high degree of flexibility, and may be pressed into all possible forms or rolled into the thinnest foils. At the temperature of boiling water the substance melts into a greasy, stringy mass, which remains unchanged until the temperature is raised to 150 deg. C. (302 deg. F.). When this point is reached, the product decomposes, forming an oily distillate. The softening of gutta-percha in hot water is done in order to remove impurities. The substance is insoluble in water, alcohol, ether, and fatty oils; it resists the majority of acids, including fluoric acid and alkalies. It can only be destroyed by concentrated sulphuric acid and nitric acid. It is easily soluble in CS_2 and chloroform, less easily soluble in benzine, turpentine oil, and petroleum. The oil obtained in the process of dry distillation of gutta-percha is an excellent solvent.

VALUE FOR INSULATION.

Gutta-percha is a poor conductor of electricity, for which reason it is most successfully used for insulation of electric cables and other electric conducts. Friction causes negative electrification. Exposed to the air, and chiefly due to the influences of air and dampness, gutta-percha turns brittle, and can then be pulverized, in which state it is soluble in alcohol and ether. This transformation is reached slowly, beginning on the surface, and gradually extending into the interior of the loaf, simultaneously the substance electrifies positively in consequence of friction. If heated with sulphur, gutta-percha vulcanizes, as in the case of India rubber, but the combination is not as close as is the case of rubber. By long vulcanizing with a large proportion of sulphur, and by adding filling materials (chalk, gypsum, coloring materials), hard rubber ("Ebonit," horny gutta-percha) similar to that obtained from caoutchouc is produced. Gutta-percha is also often mixed with India rubber in the manufacture of hard rubber, as it is said to produce an article tougher and less brittle than such as are made of India rubber alone.



AND ASSOPOS BRIDGE.

INDUSTRIAL PRODUCTS.

For industrial purposes gutta-percha is cut in a cutting machine into thin chips, which under intense motion are washed and torn to pieces in cold and later in gradually heated water, whereby sand, earth, and other impurities are separated from the mass. The latter, so purified, is then placed in kneading machines and pressed into forms in a warm, plastic state, or drawn into pipes, or rolled into thick foils, or prepared for the vulcanizing or hardening process, in the same manner as caoutchouc.

White or purified gutta-percha is handled by dentists for the temporary filling of cavities in teeth. To obtain this article one part of gutta-percha is dissolved in 20 parts of CS_2 (or benzole or chloroform) by warm digestion; the liquid is filtered through animal black, whereby it is discolored, and the solvent is removed by distillation. An absolutely white, stringy mass remains. The following is another process: The solution is mixed with a double volume of alcohol of 90 degrees Tralles, whereby gutta-percha precipitates as a white mass, while other materials and coloring matters remain dissolved. The precipitate separated from the liquid is washed with alcohol, kneaded in boiling water, and rolled out at a medium temperature into sticks of the dimensions of lead pencils. These are best preserved under water, in order to protect them against the influences of the air. White gutta-percha is frequently dyed pink, by adding carmine; when mollified in warm water it attains the highest grade of plasticity.

Gutta-percha is pressed into all possible forms, either alone or mixed with India rubber. The following articles are manufactured therefrom: Cords, tubes, pails, shoe soles, beltings, surgical instruments, knife handles, frames, etc. Gutta-percha is also used for the manufacture of dies for wood engravings, guilloche plates, etc., which are reproduced galvanoplastically. It is also largely used for paper by florists and tailors. Gutta-percha is officinal, and is used in dental practice, as mentioned above; as hoof salve for animals; and, rolled into thin foils, as gutta-percha paper, in the dressing of wounds, bruises, etc.; and, pharmaceutically, for the manufacture of traumacitin, a syrup-like, clear solution of gutta-percha in chloroform, which, applied to the skin, forms, after the evaporation of the chloroform, a transparent, flexible integument, and which, like collodion, is used externally for skin diseases, erosions, scalds, and chilblains. Gutta-percha is, however, chiefly used for insulating electric conducts; for submarine cables it is the only useful insulating material. Of late several surrogates have been utilized for gutta-percha, chiefly

Total length, 876 feet; span of main arch, 240 feet; height above river, 330 feet.

THE COMPLETED ASSOPOS BRIDGE ON THE PIRAEUS RAILWAY.

in consequence of its high price, among which balata plays an important rôle.

USES OF BALATA.

Balata is a substance belonging to the rubber-like products, and which is very similar to gutta-percha. It is obtained from the milky juice of the "Bully tree" (*Sapota muelleri Belk.*), found chiefly in the Guianas and Venezuela. This substance is obtained by felling the trees; although nowadays the bark is also cut open and the juice collected in wooden vessels. While a medium-sized tree, according to the old method (by felling) produced a quantity of from 6 to 12 pounds of balata in one process, only 0.6 to 1 pound of balsam is obtained by the method of incision; but in the latter case the bark may be cut every year.

In drying the juice in the air it is transformed into a whitish-pink or reddish substance. The latter is viscid, extraordinarily flexible, more elastic than gutta-percha, can be cut as easily as the latter, and is vulcanizable with sulphur. Friction causes electrification. At 49 deg. C. (118 deg. F.) balata can be kneaded, and it melts at 149 deg. C. (300 deg. F.). When heated, its odor is like that of gutta-percha. The substance is easily soluble in pure CS_2, and can therefore be purified without difficulty by evaporation of the filtered solution. According to Sparlich's experiments, it contains 88.5 per cent carbon and 11.3 per cent hydrogen. Balata has been known in Europe since 1859 only. It was first used in industries in Great Britain, but is now considerably consumed in Germany, particularly for making electric insulators, beltings, for soles and heels of shoes, and in dental practice. For soles and heels of shoes it is boiled with gutta-percha.

SUPPLY OF JELOTONG.

The average price of jelotong, such as Bandjermassin, Pontianak, and Sarawak, during the last five years has been 45 to 50 pfennigs per kilo (10.7 to 11.9 cents per 2.2 pounds). The price is now 58 to 60 pfennigs (13.8 to 14.3 cents) per kilo. Pontianak is the lowest grade, and is generally quoted half a cent below other kinds. At times the price has been as low as 9½ cents per kilo.

Jelotong is considerably inferior to gutta-percha, and is chiefly used as a filling material for low classes of rubber and gutta-percha goods. The article is principally brought upon the European markets by the Borneo-Sumatra Maatschappij Company, which controls the jelotong product almost entirely, *via* Singapore. London is the principal jelotong market, only small quantities being handled in Hamburg. The local importers of jelotong do not seek a market for the product outside of Germany; the supplies reaching Hamburg, mostly *via* London, are almost exclusively sold to inland manufacturers.

An American syndicate is now reported as extracting, by a certain chemical process, the rubber contained in the jelotong; the yield is said to amount to 10 per cent.

TECHNICAL SUBSTITUTES.

Several methods have been applied to produce artificial gutta-percha surrogates. According to two German patents, water, either with or without an addition of salt, is dripped on suitable substances—wax, resin, asphalt, tar, or pitch—heated to a temperature above 100 deg. C. (212 deg. F.), whereby the melting point and lentour of the latter is considerably increased. The materials so inspissated are then, either alone or mixed, stirred with caoutchouc and oils, while the temperature is gradually raised. Finally, the mass is well kneaded in heated kneading machines.

According to a Russian patent, an insulating substance for the covering of cables, etc., which may be used as a surrogate for gutta-percha, is obtained by boiling 45 parts of asphalt, adding thereto, and stirring the mass uninterruptedly, 40 parts of colophony, until a thick mass is formed; thereupon 10 parts of turpentine and 5 parts of linseed oil are poured into mass, which must be left boiling until the required lentour has been reached.

Another German patent prescribes that caoutchouc be dissolved in turpentine oil; then shellac or asphalt to be added, the mass to be heated until becoming uniform. After removing the mass from the fire, rice flour, watery agar-agar solution, and umbra is added, while it must be stirred until it congeals. Thereupon the mass is manipulated between rolls. In this manner a surrogate for gutta-percha is obtained, which may be vulcanized with sulphur, but preserves the property of being plastic, and which can be kneaded when heated.

Of late the German Telegraph Administration has, by way of experiment, laid a cable in which the insulating gutta-percha has been substituted by "Gutta Gentzsch," an artificial gutta-percha, composed of pure rubber and a certain kind of palm wax. "Gutta Gentzsch" is said to be a favorable surrogate for the real article and not to be inferior as regards insulating properties. Besides, the price of the cable was about 35 per cent lower than one insulated with natural gutta-percha would have cost.

LORD KELVIN.—II.*

HIS WORK IN TELEGRAPHY AND NAVIGATION.

BY PROF. J. A. EWING.

Concluded from Supplement No. 1799, page 407

IT is time now to turn to Lord Kelvin's work in navigation. Taking the two oldest aids to navigation, the compass and the sounding-line, he revolutionized them both. Where most men would have thought there was nothing left for invention to do, he found much. He has earned profound gratitude for appliances which add immeasurably to the security of all who go to sea. He has been called the best friend the sailor ever had; and it is said that a bluejacket was once overheard to remark, "I don't know who this Thomson may be, but every sailor ought to pray for him every night."

It was about 1873 that he began to study the compass seriously, partly because he had undertaken to write an article on it for Good Words, and partly because he had occasion to prepare, for the Royal Society, a biographical sketch of his friend Archibald Smith, containing an account of Smith's work on the theory of the perturbation of the compass caused by the magnetism of iron ships. Kelvin's first patent for an improved compass was taken out in 1876.

He found the compass full of serious defects. For one thing it was very unsteady—that is to say, it was liable to be set swinging through a large angle when the ship rolled. Sometimes an attempt was made to reduce this unsteadiness by introducing friction at the pivot, which, in a way, made matters worse by causing the compass to stick, pointing in a wrong direction. Under a mistaken idea of what would lead to steadiness, the card was made heavy and the needles long, and the long needles made it impossible to correct the compass properly for the magnetism of the ship. This was the most serious defect of all. In iron ships, and especially in ironclads, the compass is at the mercy of disturbing influences, which do much to mask the true directive force of the earth's magnetic field. To neutralize these is indispensable; the way to do it, as a matter of theory, had been pointed out, but it was only through the radical change in construction which we owe to Kelvin that it became possible to carry the process into effect.

He recognized that for this purpose the needles must be short. Further, that for steadiness what was wanted was a long period of horizontal oscillation—in other words, small magnetic moment relatively to the moment of inertia of the card; but, to keep the frictional error down, the weight of the card, including the needles, should be small. So he made the card as light as he could get it—a mere aluminium rim tied by silk threads to a small central boss, just as the rim of a bicycle wheel is tied to the nave by wire spokes, and from the silk-thread spokes he hung short pieces of magnetized knitting-needle to serve as the magnets. The result was that not only was the total weight very small, but it was nearly all in the rim, where it is most useful for giving moment of inertia and consequent slowness of period. Magnets and all, the card only weighs 180 grains for a 10-inch size, and yet its period of oscillation is much longer than that of the old standard compass, while its friction error is less.

Another admirable feature of Kelvin's invention was his method of keeping the compass always level and free from pendulum-like oscillation. He hung the bowl, as usual, from gimballs, but with knife-edges instead of the usual round spindles at the trunnions, and under the card he provided a chamber at the bottom of the bowl partly filled with castor-oil. You see this in the glass-bowl now on the table. There is a glass partition to separate the place where the compass card stands from the lower part of the bowl, and in the lower part is the castor-oil. Its function is to damp out any oscillation of the bowl that may tend to be set up by the rolling or pitching of the ship, and it does so by dissipating the energy of such swings. At the same time the knife-edge gimbails leave the compass perfectly free to take up true level.

Another feature is that the bowl and gimballs as a whole is hung from springs to withstand vibration caused by the action of the screw, or in warships by gun fire.

Now as to the correction for the magnetism of the ship. Let me indicate very briefly the nature of that problem, and how it is solved.

An iron ship is a great magnet, or rather a great aggregate of many magnets. Her magnetism at any instant springs from two causes. First, there is the more or less permanent part, which she takes up first when she is built; it depends to a great extent on how her head lay while she was on the stocks. Then there is the induced part, which changes with every change of course—a transient effect due to the induction of the earth's magnetic field. Strictly speaking, the induced magnetism is not entirely transient, nor is the other by any means entirely permanent; but the ideal division into transient and permanent is a highly useful one provided we understand the limitation within which it is to be accepted. Now think of what happens when the ship is "swung," that is, turned so that she heads successively on all points. The permanent magnetism will cause an error of the compass which will be of the same nature as you would find if you placed a compass needle on a fixed pivot and disturbed it by turning a bar magnet slowly round a vertical axis. This error will reach a maximum twice in the revolution, once to one side and once to the other side—in other words, once in each semicircle. Hence it is called the semicircular error. The permanent magnetism of the ship has a vertical component, and this causes not only semicircular error, but also a heeling error, namely, a deflection of the compass when the ship inclines to either side.

By a combination of three sets of correcting magnets, two horizontal and one vertical, Kelvin obtained complete neutralization of the disturbing effect of the ship's permanent magnetism, both as respects semicircular error in change of the ship's course and heeling error as she heels or rolls. From time to time, if the condition of perfect compensation is to be maintained, the position of these various correctors has to be altered, because of changes which take place in the so-called permanent magnetism of the ship. The navigator has always to be on the look-out for the gradual development of errors from this cause, however perfectly the first adjustment has been carried out.

We have next to consider the effects of induced magnetism. The most important of these arise from the fact that the ship is a long body of magnetizable material turning in a horizontal plane, and therefore subject to the inductive influence of the horizontal component of the earth's magnetic field. Think of what would happen if we were to take a pivoted compass needle and place it above or below a bar of soft iron, and slowly turn the bar round in a horizontal plane. We are to think of the bar as having no appreciable magnetic hysteresis, so that in every position it is the induced effect only with which we have to do. What will be the nature of the deviation? When the bar points north, and again when it points south, there is no deflection of the needle, for though the magnetism of the bar is then at its strongest, the field due to it is in the line with the undisturbed earth field; also when the bar points east or west there is no deflection, for the bar then takes up no magnetism; but between these points, namely, when the bar is point N.E., S.E., S.W., or N.W., the deflection is at its maximum. So in a ship's compass this error, due to the purely transient magnetism induced by the horizontal component of

* From the second Kelvin lecture, delivered at the Institution of Electrical Engineers.

the earth's field, has its maximum on these four courses, one in each quadrant, and for that reason it is called the quadrantal error.

It is due, as we have seen, to the ship's being a long body, extending fore and aft, and it is corrected by balancing this excess of fore and aft iron by other iron, placed quite near the compass and on either side of it. The two balls which you see on the side of the Kelvin binnacle are the correctors for quadrantal error. They are adjusted, in the first place, by selecting a suitable size of ball, and then placing them nearer to or farther from the compass until, on swinging the ship, the quadrantal error disappears. The possibility of correcting the quadrantal error in this way had been pointed out by Airy as early as 1840; but with the old form of compass card and needles it could not be done, because of the excessive length and large magnetic moment of the needles. To apply the method to a compass of the old pattern would have needed globes of impracticable size, not a few inches in diameter as these are, but weighing tons. Kelvin, with his short needles on a light card, made it possible to carry out the process, and so gave the world, for the first time, a compass that would point truly to the magnetic north, notwithstanding all the perturbations due to permanent and induced magnetism in the iron of the ship.

One more of these disturbing causes remains to be mentioned. The vertical component of the earth's fluid induces magnetism as well as the horizontal component, and gives rise to an additional error of two kinds, namely, a further semicircular error and a further heeling error. These are distinct from the semicircular error and heeling error due to permanent magnetism, and the right way to correct them is to fix a bar of soft iron in a vertical position[1] near the binnacle, so that the magnetism induced on it will act as a counter-balance. This is the Flinders bar, so called because its use was pointed out by Capt. Flinders as early as 1801. It has generally to be fixed in front of the binnacle, and in Kelvin's compass it is made in several separate lengths of soft iron, which can be put together to make up a bar giving any necessary amount of correcting effect.

The main function of the Flinders bar is to correct the semicircular error due to induced vertical magnetism. So far as the heeling error is concerned it also helps, but in practice it is found convenient to correct a part of the heeling error due to induced magnetism by means of the same kind of permanent magnet correctors as I have already described in speaking of the heeling error due to permanent magnetism, namely, vertical magnet bars placed in a can in the binnacle directly under the center of the compass card. The number and height of these bars has therefore to be altered from time to time, as the ship moves to regions where the vertical force is different. When the heeling error is fully corrected we escape one cause of the unsteadiness which a compass shows when a ship rolls, for we escape the magnetic cause of oscillation, namely, the alternate magnetic pull to port and starboard; but a purely dynamical cause of unsteadiness necessarily remains, arising from the fact that the point of suspension of a compass card must be placed some way from the center of gravity to hold the car level against the dipping action of the earth's magnetic field. Consequently, every roll to either side applies a mechanical couple tending to set up oscillation, and if the period of the roll were the same, or nearly the same, as the period of oscillation of the card, the disturbance would become so great as to make steering by compass impossible. It was to secure steadiness in this sense that Kelvin strove to give his compass card a long period of oscillation, recognizing that the right way to obtain steadiness was to make the period much longer than the period of the slowest rolling motion liable to occur in a ship, at the same time keeping the friction as small as possible. The problem of securing a steady, frictionless compass was a problem where, as in the invention of the mirror galvanometer, his genius for practical dynamics guided him to the right solution. In the case of the compass it was rendered difficult by the fact that other conditions, apparently antagonistic, had at the same time to be satisfied in order that the correction of magnetic errors might be completely carried out.

The evolution of the Kelvin compass, in its main features, took about five years; but a longer task lay before the inventor in overcoming the professional conservatism of sailors, the objections of the so-called practical man, active hostility in some quarters, and the passive resistance of official inertia. Gradually the compass came to be used in merchant vessels of the best appointed class. Enlightened navigators such as Capt. Lecky, the author of the well-known "Wrinkles," became its enthusiastic advocates. Foreign admiralties took it up, and in our own service individual officers were quick to see its merits. Capt. Fisher, now Admiral of the Fleet Lord Fisher, was warm in its praise after observing its behavior in ships under his command, first in the "Northampton" in rough weather and afterward in the "Inflexible" during the firing of heavy guns in the bombardment of Alexandria. That was in 1882; but it was not until November, 1889, that the superintendent of the Compass Department of the Admiralty was in a position to inform Lord Kelvin that his 10-inch compass was to be adopted as the standard compass for the navy. This was twelve years after the date of his patent, and more than eleven years after he had laid the invention formally before the First Lord. The way of the inventor, like that of the transgressor, may still be hard, but I trust it is not so hard now as it was then. One does not care to dwell on the spectacle of a Kelvin spending his strength in disheartening effort as the sea beats against a cliff. It is painful to read the correspondence and discussion of these weary years. One does it with increased admiration of the infinite patience which at last secured to us the benefits of his practical genius.

The use of the Kelvin compass may now be said to be universal, except that in the navy a modified form, due to Capt. Chetwynd, with a card immersed in liquid, is taking the place of the Kelvin dry card in the newer ships as being steadier still under gun-fire. The system of correction remains substantially unchanged, and the compass continues to embody the same mechanical features as formed the basis of Kelvin's invention.

In the navigational sounding machine we have another invention of first-rate importance, second only to the compass in practical value to sailors, and remarkable for its extreme simplicity. It was his cable-laying experience that first led Kelvin to take an interest in deep-sea sounding. The process, as then carried out, was a laborious one. The line was a rope an inch and a half in circumference, and though it carried a very heavy sinker, the resistance to its motion through the water was so great that it took a long time to reach the bottom. For the same reason the ship had to be stopped while the line ran out, and, except in shallow water, while it was being heaved in. many hands were needed, and much time was spent in making a cast. Hence it came about that the operation of sounding, beyond the use of the hand-lead in quite shallow water, was but little resorted to as an aid to navigation, notwithstanding the importance of the indications it could give in such cases as when a ship was approaching land in a fog or in circumstances which made the exact position uncertain, when the depth might be anything up to, say, one or two hundred fathoms.

I have spoken already of Thomson's study of the forces acting on a cable during its submersion. Applying these principles to the sounding-line, he recognized that to make the line slip down quickly it should have the smallest possible and the smoothest possible surface, and this led him to use a single wire of steel—the steel of high tensile strength used in pianofortes. In 1872 he demonstrated the practicability of using wire by taking a sounding and finding bottom at 2,700 fathoms in the Bay of Biscay with a 30-pound sinker and a single wire of No. 22 gage. He soon devised a suitable drum and winding-in wheel for deep-sea use, and from this was developed later a compact form of navigational sounding machine by which flying soundings are taken without stopping the ship.

In a flying sounding the wire streams out behind, taking an oblique course to the bottom, and the length of wire that runs out is greatly in excess of the depth. To read the depth directly, Thomson invented several forms of depth gage, the simplest of which is a long narrow glass tube, closed at the top, and coated inside with chromate of silver or some other chemical which is discolored by the action of sea water. This tube is put in a protecting case, which is attached near the sinker, and as it descends the increased pressure forces the sea water up into it, compressing the air, and indicating the depth by the height to which the chemical lining is discolored. Accordingly, the depth is read off by laying the tube against a scale, when the line is drawn on board.

This machine has become a standard navigational appliance. The length of wire in common use is 300 fathoms. A strand of seven fine steel wires, which gives greater flexibility, is now substituted for the single wire. It runs out under a regulated tension, supplied by a rope brake, which retards the rotation of the drum on which the wire is wound. When the sinker touches bottom the tension is at once seen to slacken, or rather felt to slacken by a sailor who keeps a little rod of wood lightly pressed against the wire while it runs out; the drum is stopped, and the wire is slowly wound in again by hand, or in the latest naval type by electric motor. Lord Kelvin's final improvements in the machine were made only a year or so before his death; they were, in fact, his last serious inventive work. They include a large horizontal dial for reading the number of fathoms of wire out, and with this it is often practicable to tell the depth very closely without resorting to a depth gage at all; for in the modern machine the action is so uniform that, at any given speed of ship, a definite relation holds between the depth and the length of wire out, and by finding this relation once for all a table can be prepared by which the speed is known, and so when the length of wire out is observed the depth may be at once inferred. This system is now in regular use in the navy. A pair of the Kelvin machines stands on the bridge; the wire runs out along a boom at either side and over an ingeniously designed pulley or fair-lead; whenever soundings are wanted they can be taken systematically and in quick succession while the ship proceeds at undiminished speed, and the depth is called out for the information of the navigating officer almost as soon as the wire had stopped running out. Alike in the navy and the merchant service, there is no difficulty in making it a matter of routine to keep the sounding machines going incessantly when near shore or within, say, a hundred fathoms in thick weather.

In attempting this account of the work of Kelvin in telegraphy and navigation, I am embarrassed by its volume and its range. The time has proved far too short for a fitting notice of discoveries and inventions so various, so fundamental, so far-reaching in their practical effects. Yet we have dealt only with a very small part of the whole achievement of a man not less remarkable for sustained industry than for outstanding originality—a man incessant in action and in thought—of whom it may be truly said that there is no department of physics on which he has not left an abiding impress.

I have said nothing of the lofty flights of scientific imagination, which are, perhaps, his highest title to fame; but I have said enough to show that Kelvin was no mere philosopher with head in the clouds. He was quick to recognize a real need, quick also to see how the need should be met. He found material for invention in the most commonplace appliances, because his mental habit was in everything to seek for the how and the why and to ask himself in what way the thing might be done better. He had an infinite faculty of taking pains, of adhering to a purpose until he secured its full accomplishment, of going on from improvement to improvement in pursuit of the more perfect result, and with all this a courage and hopefulness that never accepted defeat.

[1] That is to say, vertical when the ship is on even keel, or perpendicular to the deck.

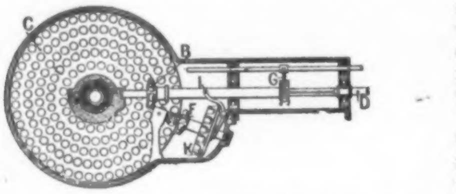
Some interesting facts are being brought out by investigations of the effect of high voltages on insulating material by Mr. H. S. Osborne, who is carrying out work for the degree of Doctor of Engineering at the Massachusetts Institute of Technology. At a recent meeting of the Boston section of the American Institute of Electrical Engineers, which was held at the electrical engineering laboratories of the Institute of Technology, Mr. Osborne lectured on the results of his experimental research. He briefly presented the results in an interesting and effective manner, and set forth theories of the effect of high voltage on insulating materials which are in closer harmony with experimental facts than the theories usually stated. The lectures of Prof. Harold Pender for graduate students will next year extend the discussion contained in his advanced lectures of this year on the high-voltage alternating transmission and utilization of power. The general treatment of the transmission circuit contained in his lectures of this year will be repeated and extended, and more attention will be given to the conditions arising from the utilization of the power. Prof. Jackson's lectures for graduate students on the organization and administration of public service companies have this year dealt more particularly with questions of value of plant, the theory of so-called intangible values, the relation of revenues to value of the plant, depreciation, and the like; and next year the lectures will be directed more to the theory underlying methods of charging for service by public service companies, with particular reference to charges for electric light and power but with collateral consideration of railroad and tramway charges and charges for gas and the service of other public utilities. Prof. Wickenden will originate a course of lectures on illumination, photometry, and illuminating engineering which will become a part of the optional curriculum for undergraduates and graduate students.

A brief paper was presented by Dr. Paul Héroult in which the hypothesis was brought out with great force that gases in steel are harmless, and that they do not produce blowholes. Blowholes are the result of disengagement of carbon monoxide, due to the interaction of carbon and iron peroxide at the time of solidification. Hydrogen, nitrogen, etc., gases are harmless; they are contained to about the same extent in Bessemer, basic, acid open-hearth, crucible or electric steel.

AUTOMOBILE NOVELTIES.*

AUTOMOBILE SPEED CHANGER WITH SPHERICAL TEETH.

The idea of employing wheels with teeth of spherical curvature, in a speed changer for automobiles, is not new. A device containing a disk studded with hemispherical projections was shown at a recent exhibition. The speed changer here described has a similar disk, in which the projections are replaced by hemispherical depressions. These depressions are arranged in concentric circles and engage with the spherical teeth of the pinion which terminates the transmission system and which can slide on its shaft. The speed varies according to the diameter of the ring of depressions with which the pinion engages. In reversing, this pinion *B* is moved back until a sleeve attached to it strikes the lever *I*, which pushes inward another pinion *F* and causes its spherical teeth to engage with the outermost ring of depressions of the disk. At the same time the teeth of the first pinion *B* engage with the spherical depressions of the crown wheel *K*, which is keyed to the shaft of the second pinion *F*, thus causing the latter to turn the disk, *C*, at minimum



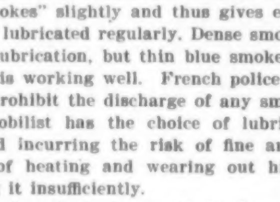
SPEED CHANGER WITH SPHERICAL TEETH.

speed, in the reverse direction. These changes are made possible by temporarily displacing the disk on its shaft and thus disengaging it from the pinions.

AUTOMOBILE SMOKE REDUCER.

When an automobile motor is properly lubricated, i. e., when the friction between the piston and the cylinder is lessened by a small quantity of oil, the exhaust gas has a bluish tint. In other words, the motor "smokes" slightly and thus gives evidence that it is being lubricated regularly. Dense smoke indicates excessive lubrication, but thin blue smoke shows that the motor is working well. French police regulations, however, prohibit the discharge of any smoke. Hence the automobilist has the choice of lubricating sufficiently and incurring the risk of fine and imprisonment, or of heating and wearing out his motor by lubricating it insufficiently.

Dubreuil has devised a method of suppressing or making invisible the small quantity of smoke which is always produced by a properly lubricated motor. For this purpose he attaches to the outlet of the muffler a filter which retains the fine ill-smelling smoke particles and discharges a colorless and odorless gas into the atmosphere. The filter is composed of four flat sheet iron boxes, measuring 8 x 10 x 2 inches, which



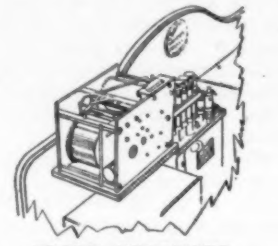
AUTOMOBILE SMOKE REDUCER.

are connected by tubes and are filled with a mixture of porous charcoal and amianthus, which opposes no appreciable resistance to the discharge of the products of combustion and, consequently, consumes none of the energy of the motor.

As the prohibition of smoke is confined to cities the apparatus is provided with a valve by which it can be disconnected in the open country, in order to prolong the life of the filter, although the filtering mixture can be renewed with little trouble or expense. A single charge is found to work satisfactorily for at least six months, when used four hours daily. The apparatus occupies little space, weighs less than 7 pounds and can be instantly attached to any automobile.

A NEW SPEED RECORDER FOR AUTOMOBILES.

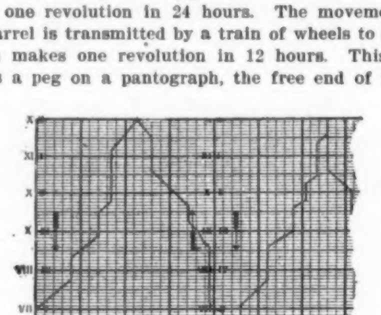
Many types of speed recorders for automobiles have been invented. Perfection has not yet been attained, but the defects of the older devices are gradually being eliminated. The apparatus here described, like some of its predecessors, is designed to indicate, at any instant, the actual speed of the car and the distance it has traversed since it started, and also to inscribe on a sheet of paper a permanent record of the varying speed of the vehicle. In older speed recorders the paper is carried by a drum which is turned with uniform velocity by clockwork and the stoppages of the car are indicated by horizontal traces. Hence, for a day's touring it is necessary to use a very long strip of paper, which must be unrolled in order to read the record of the day's performance. In the new autometer this inconvenience is suppressed by having the



SPEED RECORDER.

paper drum driven by the wheels of the car. Whenever the car stops the drum stops also, and the record of speed is so greatly compressed that, at the end of the day, it can be read without unrolling the paper. The writing point is operated by a clockwork which requires winding only once in 15 days. The entire apparatus is inclosed in a small locked box, so placed that the driver can read the record at any instant.

The motion of the wheel of the car is transmitted to the paper drum by a flexible system which terminates in an endless screw and a train of toothed wheels and pinions. The barrel of the clock which operates the writing point is driven by a spiral spring and controlled by an escapement which allows it to make one revolution in 24 hours. The movement of the barrel is transmitted by a train of wheels to a cam which makes one revolution in 12 hours. This cam moves a peg on a pantograph, the free end of which

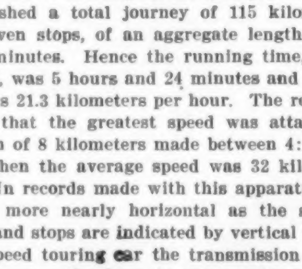


RECORD MADE BY SPEED RECORDER.

carries the writing point. The peg is constrained to move in a vertical slot and the cam is so formed that the peg and, consequently, the writing point, move with uniform velocity. The paper is divided into hour, half-hour, and five-minute spaces by horizontal lines, and into 25-kilometer and 5-kilometer spaces by vertical lines. From the record herewith reproduced it is apparent, at a glance, that the car, starting out at 7 A. M. and returning to its garage at 6:21 P. M., accomplished a total journey of 115 kilometers, and made seven stops, of an aggregate length of 5 hours and 57 minutes. Hence the running time, with stops deducted, was 5 hours and 24 minutes and the average speed was 21.3 kilometers per hour. The record shows, further, that the greatest speed was attained in the short run of 8 kilometers made between 4:50 and 5:05 P. M., when the average speed was 32 kilometers per hour. (In records made with this apparatus the trace becomes more nearly horizontal as the speed is increased and stops are indicated by vertical lines.) For a high-speed touring car the transmission may be designed to cause the drum to rotate only once for 1,000 kilometers, and the record of a long tour may thus be obtained on a single sheet of paper. This new speed recorder occupies very little space and it cannot be deranged by the vibration of the car.

ELECTRIC AUTOMOBILE HORN.

An improved automobile horn, of American invention, is shown in the accompanying illustration. The

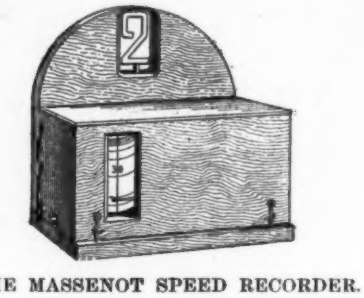


ELECTRIC AUTOMOBILE HORN.

cylinder *C* contains a small electric motor, the shaft of which ends in a ratchet wheel *R*. In front of this wheel is a thin sheet of very elastic iron which bears at its center a piece of steel, *P*. The horn is mounted in front of this iron membrane. As the wheel turns, the engagement of its teeth with the piece of steel causes the membrane to vibrate and the horn to emit a very loud sound of peculiar and indescribable quality.

THE MASSENOT SPEED RECORDER.

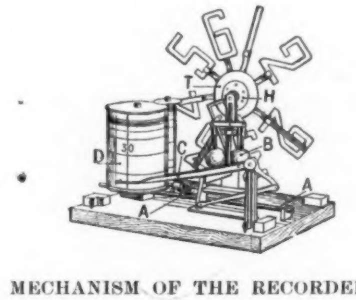
Drivers of automobiles are often arrested for exceeding the speed limit on the judgment of a policeman who makes an approximate, and possibly very erroneous, estimate of the speed of the car as it passes him. This injustice is obviated by the Massenot speed recorder, which can be read at a considerable distance. The apparatus is very simple, though rather bulky—a defect which the inventor may succeed in remedying. The motion of the wheels of the car is transmitted by a flexible system to a horizontal shaft (*A* Fig. 2). A governor, *B*, geared to this shaft, moves a lever, *C*, the point of which traces a



THE MASSENOT SPEED RECORDER.

line on a sheet of paper carried by a rotating drum, *D*, which is driven by a toothed wheel on its shaft engaging with an endless screw on the shaft, *A*. The angular velocity of the drum, therefore, is proportional to the speed of the vehicle. The recording lever, *C*, carries a toothed sector, which engages with a pinion, *H*, on the shaft of a disk, *T*. This disk bears around its periphery a series of large figures (1, 2, 3, 4, 5, 6), so arranged that the figure which is uppermost indicates the speed of the car at that instant. That this is possible is evident from the fact that the disk is turned by the lever, *C*, which is moved by the governor geared to the wheels of the car. The figures are spaced unequally, because the governor moves less for a given increment of speed at high than at low speeds.

The apparatus is inclosed in a wooden case having openings through which the drum and the uppermost figure of the disk can be seen. This figure is visible from behind and in front, so that it can be seen both



MECHANISM OF THE RECORDER.

by the driver and by any person on the road within a certain distance in front of the car.

The spherical colored halo which is often observed in brown mica always surrounds a minute crystal of zirconite or apatite, both of which minerals contain comparatively large quantities of radium. The mean radius of the halo is about 0.0016 inch, or approximately equal to the maximum distance to which mica is penetrated by the alpha rays of radium and uranium. Hence Jolz infers that the halo is produced by these rays. Rutherford has observed a similar effect in glass exposed to the action of alpha rays. A large quantity of pure radium emanation was condensed in a capillary tube of soda glass having an external diameter of 0.024 inch, where it was allowed to remain about one month, during which the greater part of the emanation became converted into other substances. When the tube was afterward examined with the microscope, the capillary bore was found to be surrounded, through its whole length, by a very sharply defined reddish zone, the inner surface of which was everywhere 0.00154 inch distant from the outer surface of the bore, although the diameter of the bore varied greatly in different parts of the tube. The coloration was evidently produced by alpha rays emitted by the emanation.

* La Nature.

BY AIR ACROSS THE ATLANTIC OCEAN.

A PROJECTED AERIAL VOYAGE FROM EUROPE TO AMERICA.

BY DR. EUGEN ALT.

THE brilliant success which has been attained by scientific and practical aeronautics in recent years has suggested several important projects, the accomplishment of which would rank with the most notable of human achievements. A voyage to the North Pole in a Zeppelin aerial cruiser is one of these projects, which has enlisted the interest and aid of eminent

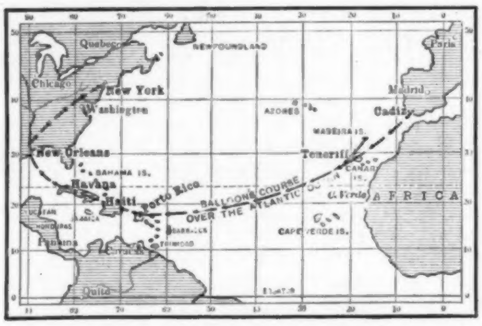


FIG. 1.—THE PROJECTED COURSE OF THE BRUCKER AIRSHIP.

Distances: Cadiz to Teneriffe 812 miles; Teneriffe to San Juan, Porto Rico 3,249 miles; San Juan to Havana 1,130 miles; Havana to New Orleans 678 miles; New Orleans to New York 1,390 miles; total, 7,259 miles.

men of science. Another is the crossing of the Atlantic Ocean in an airship. Priority in the suggestion of this idea may fairly be claimed by the well-known German-American journalist, Joseph Brucker. The preparations for the flight have been confined to a committee, headed by Dr. Gans-Fulrice, which has already solved some of the technical and financial difficulties of the problem.

The question, whether it is already possible to cross the ocean in an airship, depends for its answer chiefly upon meteorological conditions. Of the five zones into which the earth's surface is divided, we are here interested only in those parts of the tropical and temperate zones which are occupied by the ocean. The meteorological character of these regions is briefly characterized by Koeppen, as follows:

"The two temperate zones, between latitude 30 deg. and the polar circles, are marked by the preponderance of westerly winds, great fluctuations, increasing toward the poles, in the barometer, thermometer, direction and intensity of the winds and, at latitudes above 45 deg. by uncertainty in the distribution of rainfall and snowfall in time and space, and finally, by the frequency of storms, especially in the winter season.

"The tropical zone is characterized by uniform high temperature, remarkable constancy of the barometer, thermometer and the strength and direction of the wind, definite limitation of rainfall in space and usually also in time, a great preponderance of easterly winds throughout the year or in certain seasons, and the occurrence of terrific hurricanes, but only at long intervals, and in certain regions and certain months of the year. This zone is bounded, about 30 deg. north and south of the equator, by areas of high barometer, but the middle of the zone is occupied by a belt of low pressure which lies usually a little north of the equator."

The winds are determined by this distribution of air pressure. During the entire year northeast and southeast winds, which are called the trade winds, blow obliquely from the areas of high pressure toward the equatorial belt of low pressure, which is frequently marked by the total absence of wind and is therefore called "the belt of calms."

It is evident from this description that the crossing of the ocean with an airship can be accomplished only in the tropical zone and in the belts of the trade winds. The first airship must be wafted across the Atlantic by the same winds that brought the fragile caravels of Columbus to the New World. The belt of the northeast trades is the path marked out by Nature for the aerial transatlantic liner (Fig. 1).

The limits of 30 deg. north and south which were assigned to the tropical zone, including the belt of calms and the northeast and southeast trades, are average limits. In the course of the year the entire system of winds is shifted in such a manner that in the summer of each hemisphere the exterior limit of the trade wind is farther from the equator than in winter. The following table shows the average northern limits of the northeast trade wind, and the latitude of the strongest breeze, in various months of the year in the middle of the Atlantic Ocean.

Month.	Average northern limit.	Latitude of strongest wind.
January	26.5 deg. N.	15 deg. N.
April	27.5 deg. N.	15 deg. N.
July	30.0 deg. N.	20 deg. N.
October	27.0 deg. N.	18 deg. N.

Hann, in his treatise on meteorology, says of the trade winds: "They are characterized by the constancy with which they blow at any given point of the earth's surface. The current of the trades is regular and uniform. Storms, shifts of wind and calms are very rare in the middle of the trade-wind belts. The average velocity of the wind, in these middle parts, is 20 to 26 feet per second. The trade wind is always stronger in winter than in summer."

The question, which season of the year is most propitious for the ocean crossing, is to be regarded from several points of view. The place from which the start shall be made is quite as important as the probable place of landing. The time of starting must be decided chiefly by considerations of safety and the avoidance of dangerous cyclones and thunder storms.

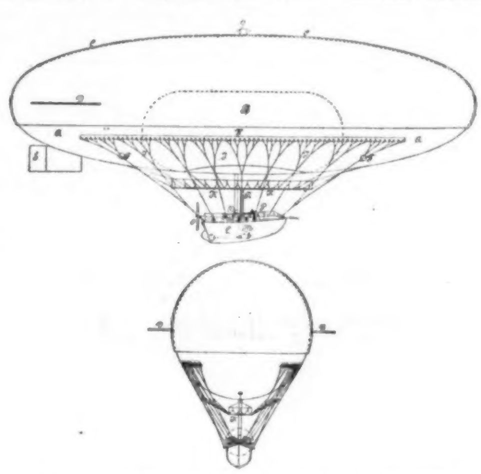


FIG. 2.—LONGITUDINAL AND TRANSVERSE VERTICAL SECTIONS OF THE BRUCKER AIRSHIP.

a, gas bag; b, filling tube; c, ballonet; d, stabilizing planes; e, rudder; g, air outlet; h, webbing supporting gondola; i, tackle; k, platform; l, motor boat gondola; m, motor; n, ventilator; o, aerial propeller; p, mast; r, rope ladder.

Cyclones almost never occur within ten degrees of the equator. Just beyond these limits cyclones occur, though often only at long intervals. The following table gives the percentage, for each month of the year, of the 95 West Indian cyclones recorded between 1878 and 1900:

Jan.	Feb.	March.	April.	May.	June.
0	0	0	0	1	3
July.	Aug.	Sept.	Oct.	Nov.	Dec.
3	26	26	34	4	3

These figures prove conclusively that the flight should be attempted in winter, at which season, furthermore, the greater strength of the trade wind promises a quicker passage.

It is very favorable to the accomplishment of the passage that both the daily and the annual variations of temperature, in the stratum of air lying immediately over the ocean, are very small. The average temperatures of the surface water of the Atlantic Ocean, in various months of the year, are given in the following table:

	Jan.	Apr.	July.	Oct.
10-20 deg. N. lat.	74.3	72.7	77.5	79.9 deg. F.
35 deg. N. lat....	63.3	63.5	72.9	71.6 deg. F.

On the open sea, the difference in temperature between the water and the air is very small. It is somewhat greater along the coast, especially where strong land and sea breezes prevail. The daily variations in temperature of air and water in the North Atlantic, at lat. 30, in summer are given in the following table:

Hour	1	3	5	7	9	11 A.M.
Temp. of water.	67.6	67.5	67.6	67.6	68.0	68.2 deg. F.
Temp. of air....	66.0	66.0	66.2	66.6	67.3	68.4 deg. F.
Hour	1	3	5	7	9	11 P.M.
Temp. of water.	68.2	68.2	68.2	68.0	67.8	67.6 deg. F.
Temp. of air....	69.1	69.1	68.5	67.5	66.7	66.2 deg. F.

In the winter months all of these temperatures are lowered, but retain their relative positions. The important point for our investigation is the fact that the daily variation of temperature is only about 3 deg. F.

Trabert says: "The tropical climate is distinguished by uniformity of temperature. The contrast between summer and winter is replaced by a contrast between a rainy season and a dry season. The trade wind is usually a comparatively dry wind, accompanied by clear sky, unless the course of the wind is interrupted by a chain of mountains, which cause precipitation of rain. Showers, indeed, occur in the trade wind belt far from land, but these showers are usually light and of short duration."

After this brief description of the meteorological conditions I will give a few data concerning the construction of the airship and the probable course of its flight. The balloon will be elliptical or cigar-shaped, with a length of about 160 feet and a maximum diameter of 50 feet (Fig. 2). It will carry, in addition to horizontal and vertical rudders and stabilizing planes, a platform made of light material, which will be suspended beneath the gas bag to afford support for several men, employed in operating the valves, pipes, etc. The usual car or gondola will be replaced by a seaworthy boat, about 30 feet long and 9 feet wide (Fig. 3). In the hold of this boat will be placed a motor which will serve either for the propulsion of the boat in the water or for driving the aerial propeller of the airship. The motor and its appendages will be characterized by solidity and strength of construction, in order to insure safety, even at the cost of speed. A powerful and relatively heavy motor, with firmly installed bearings, will guarantee a certainty of operation which cannot be assured by the light motors and weak bearings which are usually employed in airships. The size of the new airship will make it possible to carry a supply of gasoline which will make the completion of the flight reasonably certain, even under disadvantageous conditions.

The technical details of construction will be worked out by Riedinger, the well-known airship constructor of Augsburg. The material will be furnished by Metzeler of Munich, and the motor boat will be built by Luerssen of Bremen.

One of the most important equipments of the airship is the device for mitigating the injurious effects of solar radiation. As we have seen, the variation in the temperature of the atmosphere is too small to produce any appreciable variation in the temperature of

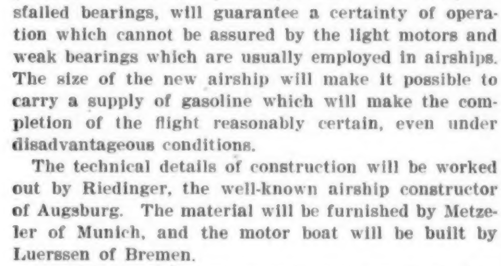


FIG. 3.—THE MOTOR BOAT GONDOLA.

the gas in the balloon. On the other hand, the rays of the tropical sun will exert an enormous heating effect upon the balloon, causing great loss of gas, even if a very large ballonet is employed. Preliminary experiments have proved that by covering the upper part of the balloon with a protective envelope of suitable material at a distance of 4 or 6 inches from the skin of the gas bag the injurious effects of solar radiation can be very greatly diminished. Additional experiments will be required to decide upon the material and

the form of construction which will best accomplish this purpose.

It is impossible in this brief sketch to discuss all of the problems involved in assuring the successful prosecution of this enterprise. Among these are the taking of water ballast from the ocean and the accurate determination of the place of the airship from observations made on board.

Madeira or Teneriffe is regarded as the most favorable starting point. If at the time of starting the trade wind should not happen to extend so far north, the airship could soon move southward into the trade wind region by the power of its engines, and could thence proceed under the combined influences of the wind and its own motive power. The time occupied in crossing the ocean is expected to be five or six days, but the airship will be equipped and provisioned for a journey of considerably longer duration. The landing will probably be made upon one of the West India islands.

What would be gained by the successful accomplishment of this project? Apart from the sportive interest of the attempt, it presents some fascinating prospects. There can be no doubt that within a short time we shall have airships capable of making speeds of 60 or 70 feet per second. If we estimate the velocity of the trade wind at 23 feet per second, we find that such an airship going to windward could accomplish 1,450 miles per day. Hence, the passage from the old to the new world, through the belt of the trade wind, could be accomplished in about 50 hours. It is unnecessary to insist upon the importance of so expeditious a crossing.

Furthermore—and herein lies the scientific and practical value of the flight for meteorology and aviation—the repetition of such aerial transatlantic journeys would very greatly increase our knowledge of the atmospheric conditions in the zone of the trade winds, and would advance the study of purely aeronautical problems, by means of practical experiments in almost ideal conditions.—Translated for the Scientific American from Umschau.

THE WHITE MAN VERSUS THE SAVAGE.*

THE ALLEGED WONDERFUL SENSES OF THE SAVAGE.

BY PROF. R. S. WOODWORTH.

Are the statements of many travelers, ascribing to the "savage" extraordinary powers of vision, hearing and smell, substantiated by exact tests? The common opinion, based on such reports, is, or has been, that savages are gifted with sensory powers quite beyond anything of which the European is capable; though Spencer explains that this is a cause of inferiority rather than the reverse, because the savage is thus led to rely wholly on his keen senses, and to devote his whole attention to sense impressions, to the neglect and atrophy of his intellectual powers. Ranke, however, on testing natives of Brazil, a race notable for its feats of vision, found that their ability to discern the position of a letter or similar character at a distance, though good, was not remarkable, but fell within the range of European powers. The steppe-dwelling Kalmuks, also renowned for distant vision, being able to detect the dust of a herd of cattle at a greater distance with the naked eye than a European could with a telescope, have also been examined; and their acuity was indeed found to be very high, averaging considerably above that of Europeans; yet only one or two out of the forty individuals tested exceeded the European record, while the great majority fell within the range of good European eyes. Much the same result has been obtained from Arabs, Egyptians and quite a variety of peoples. Among the most reliable results are those of Rivers on a wholly unselected Papuan population. He found no very exceptional individual among 115 tested, yet the average was somewhat better than that of Europeans. I had myself, through the kindness of Dr. McGee, the opportunity of testing individuals from quite a variety of races at the St. Louis Fair in 1904, and my results agree closely with those already cited, though I did not find any cases of very exceptional powers among about 300 individuals. There were a number who exceeded the best of the 200 whites whom I also tested under the same conditions, but none who exceeded or equaled the record of a few individuals who have been found in the German army. Indians and Filipinos ranked highest, averaging about 10 per cent better than whites, when all individuals of really defective vision were excluded. The amount of overlapping is indicated by stating that 65-75 per cent of Indians and Filipinos exceeded the average for whites. It did not seem possible, however, to assert anything like a correspondence between eyesight and the degree of primitiveness or backwardness of a people; since, for instance, the Negritos of the Philippine Islands, though much more primitive than the Malayan Filipinos in their mode of life, and, indeed, the most primitive group so far tested, were inferior to the Filipinos, and, in fact, as far as could be judged from the small number examined, no whit superior to whites. Nor does it seem possible, from results hitherto reported, to believe in a close correspondence between keen sight and dark skin, though it is true that pigment is important in several ways to the eye, and that, therefore, as Rivers has suggested, the amount of pigmentation might be a factor in vision. But it does not seem to be specially the darkest races that show the keenest vision. We may perhaps conclude that eyesight is a function which varies somewhat in efficiency with difference of race, though with much overlapping. No doubt, however, the results as they stand need some qualification. On the one hand inclusion of individuals with myopia and similar defects would lower the average of Europeans considerably more than that of most other races; so that the actual condition of eyesight differs more than the results show. On the other hand, it would not be fair to include near-sighted individuals, if what we wish to discover is native differences between peoples; for the different prevalence of myopia is certainly due to the differing uses to which the eye is put. And this matter of use may have considerable influence on the individuals not classed as near-sighted, and so admitted to the comparison. Rivers has made an observation in connection with the test for eyesight, which I am able to confirm, and which is perhaps of much importance. He found that when the letter or character used in his test, the position of which had to be recognized at the greatest possible distance, was removed from him beyond the distance at which he felt that he could judge it, he could still guess it right nearly every time, though without confidence. By such guessing, one's record in this test can be bettered considerably; and careful study enables one to see the slight and blurred indications of position which form the basis of the guessing. Now it may well be that the occupations of civilized life breed a habit of dependence on clear vision, whereas the life of those who must frequently recognize objects at a great distance breeds reliance on slight indications, and so creates a favorable attitude for the test of eyesight. When this possibility is taken in connection with the deterioration of many European eyes from abuse, and in connection with the observed overlapping of all groups tested, the conclusion is not improbable that, after all, the races are essentially equal in keenness of vision. Even if small differences do exist, it is fairly certain that the wonderful feats of distant vision ascribed to savages are due to practice in interpreting slight indications of familiar objects. Both Rivers and Ranke, on testing some of the very individuals whose feats of keen sight seemed almost miraculous, found that, as tested, they had excellent but not extraordinary vision. A little acquaintance with sailors on shipboard is enough to dispel the illusion that such feats are beyond the powers of the white man.

The hearing of savages enjoys a reputation, among travelers, similar to that of their sight; but there can be little doubt that the cause is the same. In fact, the tests which have so far been made tend to show that the hearing of whites is superior. Such was the result of Myers on the Papuans, and of Bruner in his extensive series of measurements made at the St. Louis Fair. Only 15 per cent of 137 Filipinos tested did as well as the average of whites; other groups made a somewhat better showing, but all seemed inferior on the average to whites. In spite of the experimental results, there is perhaps reason to doubt that the hearing of whites is essentially and natively much superior to that of other races. Civilized life protects the ear from some forms of injury to which it is exposed in more primitive conditions; and, then, the question of cleanliness must be considered in regard to the meatus. Besides, the ear is known to be highly susceptible of training in the perception of particular sorts of sound—as overtones and difference tones—and it is likely enough that the watch ticks and similar clicks used in the tests are not equally within the repertory of all peoples.

Much the same can be said regarding keenness of smell. On account of the high olfactory powers of dogs and some other lower animals, it has often seemed natural and proper that this sense should be highly developed among savages; and feats of primitive folk have been reported quite analogous to those already referred to under sight and hearing. No doubt here again, special interests and training are responsible, since what few tests have been made tend to show no higher acuity of smell among negroes and Papuans than among Europeans.

The sense of touch has been little examined. McDougall found among the Papuans a number with extremely fine powers of discrimination by the skin. The difference between two points and one could be told by these individuals even when the two points were brought very close together; on the average, the Papuans tested excelled Europeans considerably in this test. On the other hand, Indians and Filipinos, and a few Africans and Ainu, tested in the same manner, seem not to differ perceptibly from whites.

The pain sense is a matter of some interest, because of the fortitude or stolidity displayed by some races toward physical suffering. It may be, and has been conjectured, that the sense of pain is blunt in these races, as it is known to be in some individuals who have allowed themselves to be burned without flinching, and performed other feats of fortitude. The pain sense is tested by applying gradually increasing pressure to some portion of the skin, and requiring the person tested to indicate when he first begins to feel pain. Now, as a matter of fact, the results of McDougall on the Papuans, and those of Dr. Bruner and myself on Indians, Filipinos, Africans and Ainu, are in close agreement on this point. Greater pressure on the skin is needed to produce pain in each of these races than in whites. This is the average result, but in this test the distribution of the cases is specially important. Though most whites feel pain at or about a certain small pressure, there is quite a respectable minority who give no sign till much higher pressures are reached, their result corresponding very closely to those of the majority of Indians. And similarly, a minority of Indians feel pain at much lower pressures than the bulk of their fellows, falling into the ranks of the white man. In each group, the distribution is bimodal, or aggregated about two points instead of one; but whites are principally aggregated about the lower center, and Indians and other races about the higher center. Introspection comes to our aid in explaining this anomaly, for it shows that there is some difficulty in telling just when the pressure becomes painful. If one is satisfied with slight discomfort, a moderate pressure will be enough; but if a sharp twinge is demanded, the pressure must be considerably increased. Most whites, under the conditions of the test, are satisfied with slight discomfort, while my impression in watching the Indians was that they were waiting to be really hurt. The racial difference would accordingly be one in the conception of pain, or in understanding the test, rather than in the pain sense.

On the whole, the keenness of the senses seems to be about on a par in the various races of mankind. Differences exist among the members of any race, and it is not improbable that differences exist between the averages of certain groups, especially when these are small, isolated and much inbred. Rivers has in fact found such small groups differing considerably from whites in the color sense. One such group showed no cases of our common color blindness or red-green blindness, while another group showed an unusually large percentage of color-blind individuals. In the larger groups, the percentage of the color-blind is, very likely, about constant, though the existing records tend to show a somewhat lower proportion among Mongolians than among whites. Very large numbers of individuals need, however, to be tested in order to determine such a proportion closely; even among Europeans, the proportion can not yet be regarded as finally established. One thing is definitely shown by the tests that have been made for color blindness in various races: no race, however primitive, has been discovered in which red-green blindness was the universal or general condition; and this is a fact of some interest in connection with the physiology of color vision, for it seems probable that red-green blindness, since it is not by any means a diseased condition, represents a reversion to a more primitive state of the color sense. If this is so, no race of men re-

* Abstracted from a paper read before the American Association for the Advancement of Science.

mains in the primitive stages of the evolution of the color sense; the development of a color sense substantially to the condition in which we have it, was probably a prehuman achievement.

In the actual history of the discussion of the color sense in various races, quite a different view of the evolution has been prominent. It was Gladstone who first, as an enthusiastic student of Homer, was struck by the poverty of color names in ancient literature, and who suggested that the Greeks of the Homeric age had a very imperfectly developed eye for color. He was especially impressed by the application of the same color name to blue and to gray and dark objects. Geiger, adhering to the same sort of philological evidence, broadened its scope by pointing out the absence of a name for blue in other ancient literatures. It is indeed curious that the sky, which is mentioned hundreds of times in the Vedas and the Old Testament, is never referred to as blue. The oldest literatures show a similar absence of names for green. Geiger found that names for black, white and red were the oldest, and that names for yellow, green and blue have appeared in that order. He concluded that the history of language afforded an insight into the evolution of the color sense, and that, accordingly, the first color to be sensed was red, the others following in the same order in which they occur in the spectrum. Magnus found that many languages at the present day were in the same condition as that shown in the ancient Greek, Hebrew and Sanscrit. Very many, perhaps the majority, have no specific name for blue, and a large proportion have none also for green. A smaller number are without a name for yellow, while nearly all have a name for red. It seemed that the backward races of to-day had just reached the stage, in the matter of color sensation, which was attained by other races some thousands of years ago. The underlying assumptions of this argument are interesting—the notion that the list of sensations experienced by a people must find expression in its vocabulary; and the conception of certain peoples now living as really primitive. Fortunately, Magnus submitted this theory to the test of facts, by supplying travelers and traders with sets of colors, by which various peoples were tested, first, as to their ability to name the colors in their own languages, and second, as to their power to recognize and distinguish the colors. The results of this inquiry were that names were often lacking for blue and green, but that every people was able to perceive the whole gamut of colors known to the European.

This was a severe blow alike to the philological line of argument and to the ready assumption that early stages of evolution were to be found represented in the backward peoples of to-day. Accepting the facts as they stood, Magnus still felt that there must be some physiological or sensory reason for the curious lack of certain color names in many languages; and he, therefore, suggested that blue and green might be less vividly presented by the senses of many tribes, and that, being duller to their eyes than to Europeans, these colors did not win their way into the language. The theory was, however, practically defunct for many years till Rivers recently took it up, as the result of tests on several dark-skinned peoples. His test called for the detection of very faint tints of the various colors, and the result was that, as compared with twoscore educated English whom he also tested, these people were somewhat deficient in the detection of faint tints of blue—and also of yellow—but not of red. One group, indeed, was superior to the English in red. The results made it seem probable to Rivers that blue was indeed a somewhat less vivid color to dark-skinned races than to Europeans, and he suggested that pigmentation, rather than primitiveness, might be the important factor in producing this difference. A blue-absorbing pigment is always present in the retina, and the amount of it might very well be greater in generally pigmented races. The suggestion is worth putting to a further test; but, meanwhile, the difference obtained by Rivers in sensitiveness to blue needs to be received with some caution, since the Europeans on whose color sense he relies for comparison were rather few in number, educated and remarkably variable among themselves. We were able, at St. Louis, to try on representatives of a number of races a difficult color matching test, so different indeed from that of Rivers that our results can not be used as a direct check on his; with the result that all other races were inferior to whites in their general success in color matching, but that no special deficiency appeared in the blues. We also could find no correlation between ill success in this test and the degree of pigmentation. On the whole, the color sense is probably very much the same all over the world.

That linguistic evidence is a very treacherous guide to the sensory powers of a people is well seen in the case of smell. Certainly many odors are vivid enough, yet we have no specific odor names. Only a psychologist would require a complete vocabulary of sensations; practical needs lead the development of language in quite other directions.

JUPITER.

A STUDY OF THE BIGGEST OF PLANETS.

BY W. F. DENNING, F.R.A.S.

THE great and sometimes rapid changes apparent in the surface markings of Jupiter, and the comparative ease with which they may be observed in telescopes of moderate capacity, render this planet more interesting than any other for critical study. It is true that the Jovian features do not possess the stability which the Martian lineaments exhibit, nor are they of the same degree of importance; for while the former are merely formations in a mobile atmosphere, the latter are probably durable markings on the actual surface.

Since the Great Red Spot became so very conspicuous a feature on Jupiter, this planet has attracted an immense amount of interested attention. For more than thirty years the motions of the spots in the various zones and belts have been followed at every opposition, and their rotation periods determined. The velocity is different in different latitudes, and markings in the same current do not display a precisely similar period, nor is the mean value of a large number the same from year to year.

Even the Red Spot since 1901 has shown a curious oscillation in velocity, and its rate of motion seems affected by the action of a large dark mass of material in the same zone. The latter rotates in about 20 seconds less time than the Red Spot, and apparently causes an acceleration of speed in the latter whenever it overtakes it and is involved with it. I believe this suggestion was first made by M. E. Antoniadi, and is well supported by ample evidence.

The rotation of Jupiter, as fixed by various features, varies between 9 h. 48 m. and 9 h. 56½ m., and it is difficult to say what the exact period really is. The marks, having proper motions and being only temporary objects disconnected with the planet's actual sphere, do not intimate the precise rate of the axial velocity. The case of Mars is essentially dissimilar. Here we are probably dealing with actual landmarks, and the rotation period of 24 h. 37 m. 22.66 s. is reliable to within the small fraction of a second.

Studies of Jupiter are directed to finding the relative periods of the various currents at every opposition, and to making drawings of the physical aspect of the planet as exhibited in the spotted belts and zones; and micrometrical measures of the positions of the belts are valuable as showing the changes from year to year, and possibly indicating regular cyclical variations.

Observers should take as many transits of the markings as possible, and let them accumulate during a few months, when the longitudes may be computed from the ephemerides in the Nautical Almanac, and the same object identified, when their relative rates of rotation may be easily determined. These researches, when they have been continued for a long period of years, will be valuable, and may afford a clue as to the nature of the changes, and define the period of their recurrence, unless, indeed, they are the outcome of irregular atmospheric vagaries.

We owe much in recent years to the persevering study of this planet by A. S. Williams, G. W. Hough, P. B. Molesworth, T. E. R. Phillips, and many others. The data we possess is of a voluminous description, and will ultimately enable us to learn some important facts as to the physical condition of the largest planet of our system.

For the thoroughly effective study of Jupiter a telescope less than 6 inches in aperture is scarcely capable. The writer has examined the planet many times with instruments varying from 3 inches to 12½ inches, and found the larger sizes far preferable as grasping more detail. A mirror of 10 inches diameter of about 6½ feet focus can be particularly recommended for its excellent performance, and for the facility with which it may be employed. Larger glasses may show more, and this is obvious on really good nights; but for ordinary work, a 10-inch will prove itself a very efficient tool. Mr. Williams uses a 6½-inch reflector, and finds that sufficient for his purpose; but special excellence of vision and long experience have doubtless contributed to make him successful in a measure beyond what his instrumental equipment would suggest.

The Red Spot, or a marking forming some ancient prelude to it, was seen by Hooke and Cassini nearly two and a half centuries ago. But we cannot assume the actual identity of the objects though the evidence is significant. The hollow in the South Equatorial Belt near the Spot has certainly existed under some variable aspects since Schwabe figured it in September, 1831, and the writer worked out the changeable rotation of the object, and gave the results in a paper published in the Monthly Notices in 1899. Some curious vicissitudes appear to have affected the form of the hollow in recent years, and it seems in danger of losing its characteristic shape so familiar to all observers of the planet. But the changes may be only temporary, and due to cloud interferences. The Red Spot may itself regain the very conspicuous aspect it presented in 1878 and 1879 at some future time; but we cannot prognosticate the exact date of its revival. The "E. M." has largely contributed to our knowledge of Jovian phenomena. In the years 1879, 1880, and 1881, when the Red Spot was a startlingly prominent object, many hundreds of transit times were published in your columns, and Mr. A. Marth greatly accentuated the interest in the subject by computing the longitudes and deducing the rotation periods.

Usually the material of the Equatorial Zone moves quicker than other regions of the disk. The rate has varied between about 9 h. 50 m. and 9 h. 50 m. 30 s. during the last thirty years, and the irregularities of motion are difficult to understand. The great South Temperate Spot, which has varied enormously in length, rotates in about 9 h. 55 m. 20 s., and completes a revolution of the planet relatively to the position of the Red Spot, in slightly less than two years. From some observations by Mr. Scriven Bolton obtained last autumn, he concluded that the S. Temp. Spot would overtake the following end of the Red at the middle of November last, so that at the present time the two objects must be in nearly the same longitude, and we may expect an acceleration in the motion of the Red Spot.

Even with a 3-inch telescope and a power of 150 an observer may perceive a fair amount of detail on Jupiter; but the more complicated and diminutive features are hopelessly beyond such an instrument. Much may be glimpsed, but it is of a shadowy, indistinct character, and liable to occasion many doubts in the observer's mind. Any person with imaginative tendency may easily exaggerate the appearance of the planet with such insufficient means, and they are not to be recommended except to beginners, who cannot always afford large telescopes. Undoubtedly, a 3-inch will afford a most pleasing view of Jupiter to any tyro, for it displays the four old Galilean satellites, a number of the belts, and the shadows of the satellites in transit, together with a few of the larger markings.

What we really require, and what recent years have provided, owing to the perseverance of a number of really able observers, is the determination of the rate of rotation of all the principal currents on the planet at every opposition. Storing up these details for many years, and ultimately making comparisons, may lead to interesting discoveries. What seems hidden in mystery at present may admit of easy explanation when sufficient observations have accrued to enable the problem to be satisfactorily solved.—English Mechanic.

A good test for oil, states the American Machinist, is to place single drops in line upon a piece of plate glass, about 8 inches wide and 24 inches to 30 inches long, one end being raised about 6 inches to 8 inches, to form an inclined plane. The drops of oil start from the top of this inclined plane upon a race with each other. The first day sperm oil will be found in the rear, but after a while it will catch up and overtake the rest. An oil having a light body runs quickly and dries quickly, but an oil that has both a body and a free flow will readily be detected by this test. An oil may have a good body and yet may have a tendency to gum badly, which quality will also be easily detected upon the glass. The oils should be covered from dust while these tests are being made.

SCIENCE NOTES.

History tells us that Roman agriculture declined until a bushel of seed brought only four bushels in the harvest—declined until the high civilization of the Mediterranean countries passed into the dark ages which covered the face of the earth for a thousand years, until the discovery of a new world brought new supplies of food, renewed prosperity, and new life and light to western Europe; but the dark ages still exist for most of our own Aryan race in Russia and in India, where, as an average, day by day, and year by year, more people are hungry than live in the United States, where the average wage of a man is fifty cents a month, where famine rages always, and where the price of wheat sometimes rises to a point where six months' wages of a working man are required to buy one bushel. This is the condition where the absolute needs of the population exceed the food supply, and just so sure as the intelligent and influential men and women of America continue to ignore the material foundation upon which national prosperity depends, just so sure will future dark ages blot out American civilization.

The old problem of binocular vision has been recently considered again by A. Quidor. Stereoscopic perception of the notions of distance and relief is due, according to him, to the psychic synthesis of the images perceived. It is, in consequence, not governed by the precise laws of orthostereoscopy. It is characterized by the necessity for accommodation and convergence for different distances, and depends on the divergence of the visual axis. A law applicable generally in streoscopy is enunciated, viz, that retinal images of an object are always of unequal size. The relief is sterescopic when, for objects at the left of the observer, the larger image is seen by the left eye, and similarly for the right eye. An inverse disposition of the images gives pseudoscopic relief. By the aid of principles established by means of the Quidor-Nachet miscroscope, and by using the notions of absolute and relative relief, the influence of certain binocular instruments on relief is determined, the results not agreeing with those given by Fechner's law. The unity of sensation appears to be due to a particular structure of the visual apparatus.

Papers Nos. 1736 and 1741 of the Proceedings U. S. National Museum are due to the indefatigable zeal of Dr. William H. Dall, Curator of the Division of Mollusks in the National Museum. The first of these, No. 1736, is "On some Land Shells collected by Dr. Hiram Bingham in Peru," and is a report on a small collection of specimens obtained in a little-visited part of Peru. These specimens were sent to the National Museum for examination by Dr. Bingham of Yale. The collection includes the following three new species: *Bulimulus (Lissoacme) binghami, B. (L) ptyalum*, and *Clausilia (Nenia) pampasensis*, the first two of which were collected from cacti on the banks of the Rio Pampas, Peru. Types of these new species have been deposited in the National Museum. The pamphlet contains a halftone illustration of the Rio Pampas looking downstream, and also smaller illustrations of the three new species described. The second paper, No. 1741, is a "Summary of the Shells of the Genus Conus from the Pacific Coast of America in the U. S. National Museum," and perhaps may be best described as a preliminary publication of material which had been gathered in an attempt recently undertaken in the Division of Mollusks in the National Museum to revise the Western American cones and to correct their nomenclature. Several new forms, such as *Conus edaphus, C. xanthicus*, and *C. scariphus*, are described, and some species confused with others in the past are given distinctive names.

The collection of insects in the U. S. National Museum is constantly receiving additions from specimens that are sent in for examination. The report on these specimens that are submitted for study usually takes the form of papers that are published in the Proceedings of the U. S. National Museum. Two such papers have just been issued. They are: Paper No. 1739, "On a Collection of Tenthredinoidea from Eastern Canada," by S. A. Rohwer, which is a report on a series of sawflies made mainly in the county of St. John, New Brunswick, by Mr. A. Gordon Leavitt. All of these specimens came from either the Canadian or Hudsonian Life Zone in Eastern Canada, and contain species found throughout these zones. The following twelve new species are described: *Pteronus ochreatus; Pontania pumila; P. leavitti; Pristiphora idiotiformis; P. pallicoxa; Cryptocampus pallistigmus; Polybates secundus; Parabates leucostomus; Hemitaxonus rufopectus; Monsoma maura; Dimorphoteryx melanognathus;* and *Tenthredo diversiceps*, the types of all of which are deposited in the U. S. National Museum. Dr. Harrison G. Dyar, Custodian of Lepidoptera, gives in paper No. 1742, a number of "Descriptions of some new species and genera of Lepidoptera from Mexico." This author finds among the undescribed forms of moths that have accumulated in the collections of the National Museum no less than 94 new species that have been received from the Republic of Mexico, all of which are described in the present paper.

ENGINEERING NOTES.

A concrete street pavement in Richmond, Ind., laid in 1896 is still giving good service, and has not required a cent for repairs, according to Mr. Frank R. Charles, city engineer. Extreme care, he says, was taken in laying it. The sub-grade is gravel, the slab a 1:2:5 mixture, 5 inches thick after ramming, and the wearing surface a 1:2 mortar 1½ inches thick. The surface is cut into 5-foot squares and pitted with a roller. One-inch expansion joints are used at intervals of 30 feet to 40 feet, and are filled with paving pitch. The chief trouble has been due to spalling at the joints, especially along those placed longitudinally. In later pavements cutting into larger blocks has been tried in order to reduce the number of joints, but the maximum size is limited by necessary allowance of joints for temperature changes. Mr. Charles believes 15-foot squares are as large as can be used with safety in a climate like that of Richmond. In some pavements laid more recently on streets carrying heavy traffic the slab has been increased to 6 inches in thickness, and the wearing coat to 2 inches.

According to Concrete and Constructional Engineering an improvement in the method of constructing a cement cistern over the plan ordinarily recommended was recently observed by a contemporary on an Ontario farm. The method usually adopted of building an upright circular wall and covering arch at one operation involves the taking out through the manhole of all the curbing as well as the timbers supporting the arch. In this case, after the circular wall had been finished to the top of the curbing, it was allowed time to set sufficiently, and then the curbing was all taken out. The supporting frame for cement arched cover was made by cutting six or eight short rafters, with slight heel projection, resting on the inner edge of the perpendicular surrounding wall, the tops meeting over the center of the cistern. A wooden box for a manhole was set in position, the remaining space on the rafters boarded over, and the cement covering spread on the desired thickness and shape. When safe to do so, in about a week, the roof structure was easily removed from the inside, only a very few nails having been used.

The resistance of concrete to gun fire was tested practically to some extent at Port Arthur, says the Engineering Record, and different opinions have been expressed regarding the lessons to be drawn from the results there. In a general way, the objections to concrete have been based mainly on the claim that the effect of the impact against it was to crack such a large mass of material that the integrity of the structure was much weakened even beyond the immediate vicinity of the point of impact. Reinforced concrete has been suggested a number of times as a substitute for mass concrete in military works, in order to meet this objection, and some tests were recently conducted at Sandy Hook for the purpose of determining to what extent the reinforcement would limit the effect of the projectile. The results are of a confidential character, but it is understood that the success of the reinforcing rods in confining the shattering of the concrete to the immediate neighborhood of the pathway of the shot through the mass was marked. While the steel did not appear greatly to reduce the absolute depth of penetration of the projectile, it localized the damage very satisfactorily, so long as the shells did not detonate after penetrating.

TRADE NOTES AND FORMULÆ.

Resist (for Etching on Table Glassware, Tinfoil).—French oil of turpentine, 140 parts; powdered Syrian asphalt, 80 parts; beef tallow, 20 parts; white, hard stearine, 20 parts; yellow beeswax, 30 parts; Burgundy pitch, 45 parts.

Resist for Places Not to Be Etched.—For glass etching, take 4 parts wax, 4 parts asphalt, 1 part yellow pitch, 1 part black pitch, melted together and kept fluid until a cooled sample is brittle and fragile. Dissolve in camphene and apply with a brush.

To Cement Bags of Parchment.—Warm 15 per cent. gelatine solution is mixed with a solution of 3 to 5 per cent bi-chromate of potash. The glue hardens in the light, and should, therefore, be kept in black bottles. When cementing the bags, the parchment paper must be moistened.

Paint for Woven Wire.—80 parts rubber, 1,000 parts oil of turpentine, 500 parts poppy oil, 200 parts ground zinc-white, 500 parts ground dammar gum (or better, dammar varnish), 200 parts of siccative, 50 parts oil of lavender, then the mixture with poppy oil. As a final coating use pure rubber in solution.

Resist for Places Not to Be Gilded.—In electro gold plating: 2 parts asphalt, and 1 part mastic melted together, and heated with sufficient oil of turpentine to produce a mass easily applied by means of a paintbrush. After gilding brush off by means of oil of turpentine and spirits.

Copying Old MSS.—To make old writings plainly legible for copying, dissolve 150 parts of oxalate of ammonia, of potassium, or of sodium, 0.8 part of ferrocyanide of potassium, 0.06 part of vanadate of ammonia in 1,000 parts of water, and when copying use this solution to moisten the faded places.

To Bring Out the Damascening on Gun Barrels.—Close the openings of the barrel with corks and cleanse it from grease. The barrel is then laid in a sufficiently long box, lined with pitch and 1,000 parts of water poured over it, to which 30 parts of muriatic acid have previously been added. Allow it to lie in this for 3 to 4 hours, wash it off with water, polish it with fine tripoli and tow and dry it well. Grease with oil and heat over a charcoal fire.

Dinas Bricks (Dinas bricks, Flintshire bricks, quartz bricks).—Are made of pure quartz, with a small amount of binding material, lime, oxide of iron and clay, so-called after the cliffs of the same name in the valley of Neath, in South Wales, near Swansea. The white Dinas bricks resist the highest degrees of heat, and consequently form an excellent material for the lining of fireplaces, puddling furnaces, etc.

Manufacture of Dinas Bricks.—Quartz or flint is heated to redness, cooled by quenching while hot, then reduced in the stone breaker. About 1 part of the quartz, ground to a coarse powder and about 2 parts of pieces of 2 to 3 millimeters in diameter, are mixed together and stirred up with lime milk (lime paste) into a moist, friable mass. Each brick must be pressed. The burned Dinas bricks, contain about 2 per cent. of lime. An important condition is, that after burning the bricks are allowed to cool gradually in the kiln. Otherwise, there will be a great deal of breakage and the bricks will be fragile. As cement, in building, use ground Dinas fragments or quartz, also mixed with lime m'lk.

Copies in Oil Colors on Paper (Poitevin's process).—*a*. Coat paper with a solution of gelatine, made black with India ink (in Germany this is called and sold as pigment printing paper) and dip it in a solution of 10 parts chloride of iron, 3 parts tartaric acid and 100 parts water. After drying, the coating is insoluble in water. If exposed to light, under a positive line drawing, the parts exposed to light become soluble, immersed in a cup filled with warm water. A black positive picture is thus produced on a white ground. *b*. Coat paper with slightly colored gelatine, make the coating insoluble in the above bath, expose under a negative and develop. Wash well, dry and roll on printers' ink, then dip it in weakly acidified water, finally in warm water.

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